CRANFIELD UNIVERSITY

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A constitutive view on risk communication in organisations managing high-risk processes: Towards a conceptual framework.

School of Management

DBA
Academic Year: 2012 - 2013

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DISSEMINATION TO DATE

Parts of this thesis were presented at various conferences, published in academic journals, or presented in guest lectures. Other parts led to similar research and subsequent publications or presentations in the field of risk perception, risk communication, and decision-making in crisis situations.

Publications:

Marynissen, H., Pieters, S., Van Dorpe, S., van het Erve, A. M., Vergeer, F. (2010). *Geen commentaar! Communicatie in turbulente tijden (No comment! Communication in times of turbulence).* Houtekiet / Business Contact, Antwerpen – Amsterdam.

Marynissen, H. (2011). The relationship between organisational communication and perception. *Acta Chirurgicum Belgica, 11*(4), 193-199.

Marynissen, H., Ladkin, D. (2012). The relationship between risk communication and risk perception in High-Reliability Organisations, A systematic review. *Conference paper for the Second International Conference on Engaged Management Scholarship*, Cranfield, UK. http://ssrn.com/abstract=2084823

Marynissen, H. (2012). The relationship between risk communication and risk perception in complex interactive and tightly coupled organisations: A systematic review. *Society for Risk Analysis, Conference paper for the 2012 World Congress on Risk*, Sydney, Australia.

Brugghemans, B., Marynissen, H. (2013). Beslissingen nemen in complexe brandweerinterventies (Taking decisions in complex fire fighter interventions). *De Brandweerman (Practitioners' journal of the Belgian Fire Fighters Association), 89*(538), 7-8.

Brugghemans, B., Marynissen, H. (2013). The process of decision-making in a fast burning crisis situation: A multiple sequence approach of decisiveness. *International Fire Service Journal of Leadership and Management, 7*, 41-50.

Marynissen, H. (2013). Waarom communicatie niet werkt? (Why communication doesn't work?). Ad Rem (*Flemish practitioners' journal for communication professionals*), *4*, 8-10.

Marynissen, H., Ladkin, D., Denyer, D., Snoeijers, E., Van Achte, T. (2013). The role of individual risk perception in an organization managing high risks. *Conference paper for the Third International Conference on Engaged Management Scholarship*, Atlanta, GA. http://ssrn.com/abstract=2322816 (Awarded 'Best Qualitative Paper').

Presentations:

The meaning making aspects of leadership. *Discourse in Organizations (DIO), University of Antwerp, Belgium, 4 June 2010.*

The relationship between communication and perception. *Royal Belgian Society for Surgery (RBSS), Twelfth Belgian Surgical Week, Ostend, Belgium, 14 May 2011.*

Crisis. Perception or reality? *Zorgnet Vlaanderen and VVSG, Symposium on crisis communication in elderly care, Ghent, Belgium, 19 October 2011.*

The impact of communication on organisational learning. *European Corporate Compliance Exchange, London, UK, 24 April 2012.*

Danger at Work. *International Society for the Psychoanalytic Study of Organizations, ISPSO 2012 Annual Meeting, San Diego, CA, 9 June 2012.*

The relationship between risk communication and risk perception in complex interactive and tightly coupled organisations. A systematic review. *Second International Conference on Engaged Management Scholarship, Cranfield, UK, 22 June 2012*.

The relationship between risk communication and risk perception in complex interactive and tightly coupled organisations. *Society for Risk Analysis, World Congress on Risk, Sydney, Australia, 20 July 2012*.

How to deal with (social) media in a crisis situation? *Keynote presentation at the annual CFE Group Convention, Luxembourg, 28 November 2012.*

The impact of risk communication on individual risk perception in a complex interactive and tightly coupled organisation. (Marynissen, H., Ladkin, D., Denyer, D., Snoeijers, E., Van Achte, T.) *Poster presentation at the Society for Risk Analysis (SRA) Annual Meeting, San Francisco, CA, 10 December 2012.*

The role of social media as a trusted risk communication tool. (Pieters, S., Van Achte, T., Marynissen, H.) *Presentation at the Society for Risk Analysis (SRA) Annual Meeting, San Francisco, CA, 11 December 2012.*

The future of e-medicine. Crisis communication in a medical context. (Marynissen, H., Pieters, S.) *Presentation at the First European Congress on Pediatric Resuscitation and Emergency Medicine (PREM 2013), Ghent, Belgium, 3 May 2013.*

The process of decision-making in a burning crisis situation: A multiple sequence approach of decisiveness. (Marynissen, H., Brugghemans, B.) *Presentation at the 22nd SRA-E Conference*, *Trondheim, Norway, 18 June 2013.*

The role of individual risk perception in an organization managing high risks. (Marynissen, H., Ladkin, D., Denyer, D., Snoeijers, E., Van Achte, T.) *Presentation at the Third International Conference on Engaged Management Scholarship, Atlanta, GA, 20-22 September 2013.*

Guest lectures:

Managerial communication in turbulent times. *European Commission, DG HR, Masterclass communication, Brussels, 30 June 2011.*

Communicating in turbulent times. *European Parliament, Lunchtime Masterclass Middle-Management Action Programme Series, Brussels, 25 September 2012.*

Crisis communication. *For post-graduates Disaster Management, Campus Vesta (University of Antwerp), 23 February 2013.*

Risk communication. *For academic bachelors Communication Science, University of Antwerp, 26 March 2013.*

Complex Interactive Processes. *Second Master Class Risk and Crisis Management, CIP Institute, Rotterdam – Antwerp, 28-29 March 2013.*

Risk communication. *For academic bachelors Environmental and Prevention Management, University of Brussels, 17 May 2013.*

Internal communication or internal interactive processes? *For academic bachelors Communication Science, University of Antwerp, 21 May 2013.*

Leadership in a high-hazardous team. *Summer School of the Belgian Fire Fighters Association, Campus Vesta (University of Antwerp), 26 August 2013.*

ABSTRACT

This study presents a conceptual framework for a constitutive view of risk communication in organisations managing high-risk processes. Over the last decades, multiple incidents in these types of organisations indicate that the mere communication of risk information and safety procedures does not necessarily lead to risk aversive attitudes. Therefore, it might suggest that the traditional transfer of information is not fulfilling its aim, namely to keep the organisation safe. This doctoral thesis proposes a form of constitutive communication that involves all organisational members in an open safety dialogue as an alternative to this informational approach of communication. As such, it offers a way of taking into account the interpretive, subjective aspects of communication and shows how they interweave with formal communication structures to create the possibility of ongoing safe operations.

An on-shore gas-receiving terminal on the European continent was the subject for two empirical research studies. Based on multiple methods, including qualitative interviews, ethnographic data analysis, repertory grid-based interviews, and social network analysis, this study indicates how a constitutive dialogue that creates a common mindset concerning safe operations among all staff can be installed and supported. Furthermore, it demonstrates how despite the fact that every individual in this organisation has different perceptions of the present risks, constitutive risk communication leads to coordinated safe behaviour. These findings offer new perspectives on the solution-oriented knowledge about the relationship between risk communication and risk savvy in organisations managing high-risk processes.

The theoretical background to this phenomenon was supported by a literature review in the field of risk communication and risk perception in organisations managing complex interactive and tightly coupled processes. These findings, together with those of the empirical research projects, were compared with insights in the theoretical fields of High-Reliability Organisations (HRO) and Communication Constitutes Organisations (CCO), and result in a conceptual

framework for a constitutive view on risk communication in organisations managing high-risk processes.

This research offers a number of theoretical and practical contributions to the field of HROs, the field of CCO research. It not only confirms key insights into these theoretical fields, it is also the first study that links the use of CCO to organisations managing high-risk technologies.

ACKNOWLEDGEMENTS

I am very well aware of the fact that the words ‘fun’ and ‘doctoral research’ are seldom used in one sentence. However, despite the many hours, days, and weeks of interviewing, writing, discussing, interpreting, rewriting, reading, and rewriting again, despite the many nightmares filled with weird colourful diagrams and freaky data, and despite my mental absence at public and private events, this doctoral research has been one of the most enjoyable intellectual experiences I have ever had in my life.

Having said so, I do acknowledge that it would be an illusion to engage in a doctoral programme without the support of others. In that respect, this doctoral thesis project is no exception. Therefore, I would like to give a sincere and warm thank you to my supervisor, Prof. Donna Ladkin, for her critical feedback, her dedicated support, and her quick wit. Her persistent aim for a rigorous approach helped me to become a better researcher and a more reflective practitioner.

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Over the last four years, I have had the most inspiring conversations with faculty members of Cranfield School of Management. All of them had a considerable contribution to my doctoral education. One of them, the late Professor Emeritus Alan Harrison, had a very special impact on my personal development. He was a living example of not giving in, holding on to a dream, a vision, and the joy of life. You will be missed, Alan, but I am sure you would have been proud to see so many of your ‘hand-picked DBA students’ graduating. Wherever you are, this work is a humble way of honouring you and your inspiring work.

A very special thank you goes to my colleagues Stijn Pieters, Tim Van Achte and Steven Pieters for accepting my four-year absence with a smile, and liberating me from all the day-to-day troubles at work. Each of them helped me

in my thinking process and supported me to make my research applicable for the ‘real’ world. Another warm thank you goes to distant and close friends, like-minded colleagues, and fellow DBA-students around the globe. I have learned a great deal from the discussions in our collective and individual meetings. And a sincere thank you goes to Jonathan Howett for the editorial revision of this document.

This doctoral research would not have been possible without the support, trust, openness, and enthusiasm of the executive team of Gassco Belgium and all staff in Zeebrugge. I hope the findings of this research might in return help them to maintain their high standards of safe operations and constitutive risk communication.

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PART I: LINKING DOCUMENT

1 BACKGROUND AND RATIONALE

1.1 Introduction

In research as well as in industrial practice, great efforts are made to increase the safety at high-risk production systems (Grote and Künzler, 2000). Recent incidents, such as the gas explosion of a Fluxys pipeline in Ghislengien (Belgium, July 2004), the explosion at the BP Texas City Refinery which caused 15 deaths and over 170 injuries (USA, March 2005), the explosion on BP's Deepwater Horizon (Gulf of Mexico, April 2010), or a derailed train carrying highly toxic chemicals in Wetteren (Belgium, May 2013) killing one person, injuring 17 others and forcing nearly 300 people to be evacuated from their homes - just to mention a few - are all rooted in some kind of failure, be it human, systems or technical failure (Hopkins, 2005). Investigations following these disasters indicated that despite all the technological safety processes, quite often the root causes of these incidents lie in human error (Antonsen, 2009). Although employees were well trained in safety procedures, they often did not take into account the importance of these processes (Rochlin, 1999) and did not act accordingly. A Safety Review Panel that was investigating the 2005 explosion at the BP plant in Texas, for instance, indicated, in the so-called Baker Panel Report, systemic errors such as deficiencies in leadership, lines of communication, core values, and inconsistency in the messages about process safety, as the root causes of this tragedy (US Safety Review Panel, 2007). The Baker Panel listed ten recommendations "to improve BP's corporate safety culture, corporate oversight of process safety, and process safety management systems" (US Safety Review Panel, 2007; p. xvi). All of these recommendations were well documented and clearly explained. Hence, it could be argued that if all BP staff worldwide had embraced these safety recommendations, the Deepwater Horizon disaster in the Gulf of Mexico, three years later, would never have happened. It indicates that, despite the recommendations from a Safety Review Panel after a disastrous event, the existing communication tools,

and the safety trainings, the use of communication to alter employees' risk perception was underestimated (Weick, 2010) or failing. Apparently, there is a deficiency in the solution-oriented knowledge about the relationship between risk communication and risk perception.

To date, the majority of organisations managing high-risk processes disseminate information about risks to their employees through safety procedures and guidelines (Bieder and Bourrier, 2013), which is in line with a solution-oriented understanding of how knowledge is conveyed. Additionally, safety campaigns are designed and implemented according to these guidelines. The simple but erroneous assumption is that if someone knows the risks, he or she will avoid them. However, this informational approach of communication (Koschmann, 2012), in which the risks are explained, is not changing employees' behaviour (Paine, 1965) or mental models concerning risk, nor does it keep organisations accident free.

In an attempt to evaluate the impact of risk communication in organisations managing high-risk processes on employees' risk perception and subsequent risk aversive attitudes, this doctoral research asks three key questions: 1) what is the relationship between risk communication and risk perception in organisations managing high-risk processes, 2) how do people in these types of organisations perceive risks, and 3) how do people in organisations managing high-risk processes maintain safe operations? Each of these questions lay at the basis of a research project. In a first research project, the literature that focuses on the relationship between risk communication and risk perception in organisations managing high-risk processes was systematically reviewed. Its findings indicated how trainings, employees' involvement in the decision making process, and hierarchical communication might have an impact on the employees' information processing system, and consequently on their attitudes towards risks.

This led to an empirical research project that focused on how individuals in an organisation managing high-risk processes interpret risk communication and perceive risk. It turned out that all employees in the studied company have

different interpretations of the actual risks in their company. Although this research indicated that the mere dissemination of procedures, guidelines, and information about risks does not lead to a uniform view of risks among its staff, this company had been operating for more than twenty years without having faced a critical incident.

Subsequently, I empirically examined, in a third research project, how this organisation maintains safe operations despite the divergent risk perceptions among its employees. The findings indicated how all staff are involved in a continuous open safety dialogue that constitutes a risk aversive and mindful (Weick and Sutcliffe, 2007) organisation. These three projects are depicted in the figure below (Figure 1-1) and lead to a conceptual framework that will be fully explained in Chapter 3 of this first part of the doctoral thesis.

Based on the findings of my three research projects, and underpinned with the theoretical frameworks of High Reliability Organisations (HRO) and Communication Constitutes Organisations (CCO), this thesis offers an interpretivist view of a conceptual framework for risk communication in organisations managing high-risk processes. This framework aims to give an initial answer to the question how a communicative dynamic among employees might be supported and nurtured, with the aim of constituting an ongoing safety dialogue.

Earlier research in the field of High Reliability Organisations (HROs) indicates how maintaining a high degree of operational safety does not depend on a mere disseminating of rules or procedures (see for instance: Weick and Roberts, 1993; Klein et al., 1995; Rochlin, 1999; Weick and Sutcliffe, 2007), but rather on “a free flow of information at all times” (Rochlin, 1999; p. 1554) embedded in “a pattern of heedful interrelations of actions in a social system” (Weick and Roberts, 1993; p. 357). Still, it was never indicated *how* these types of interrelations have to be designed, supported, or implemented in an organisation. Although the five principles supporting HRO (Weick and Sutcliffe, 2007) and the overarching notion of “mindful organising” (Weick and Sutcliffe, 2007; p. 148) give directions for anticipating and containing incidents, they offer

no clear answers on the practical communicative aspects that enhance incident free operations.

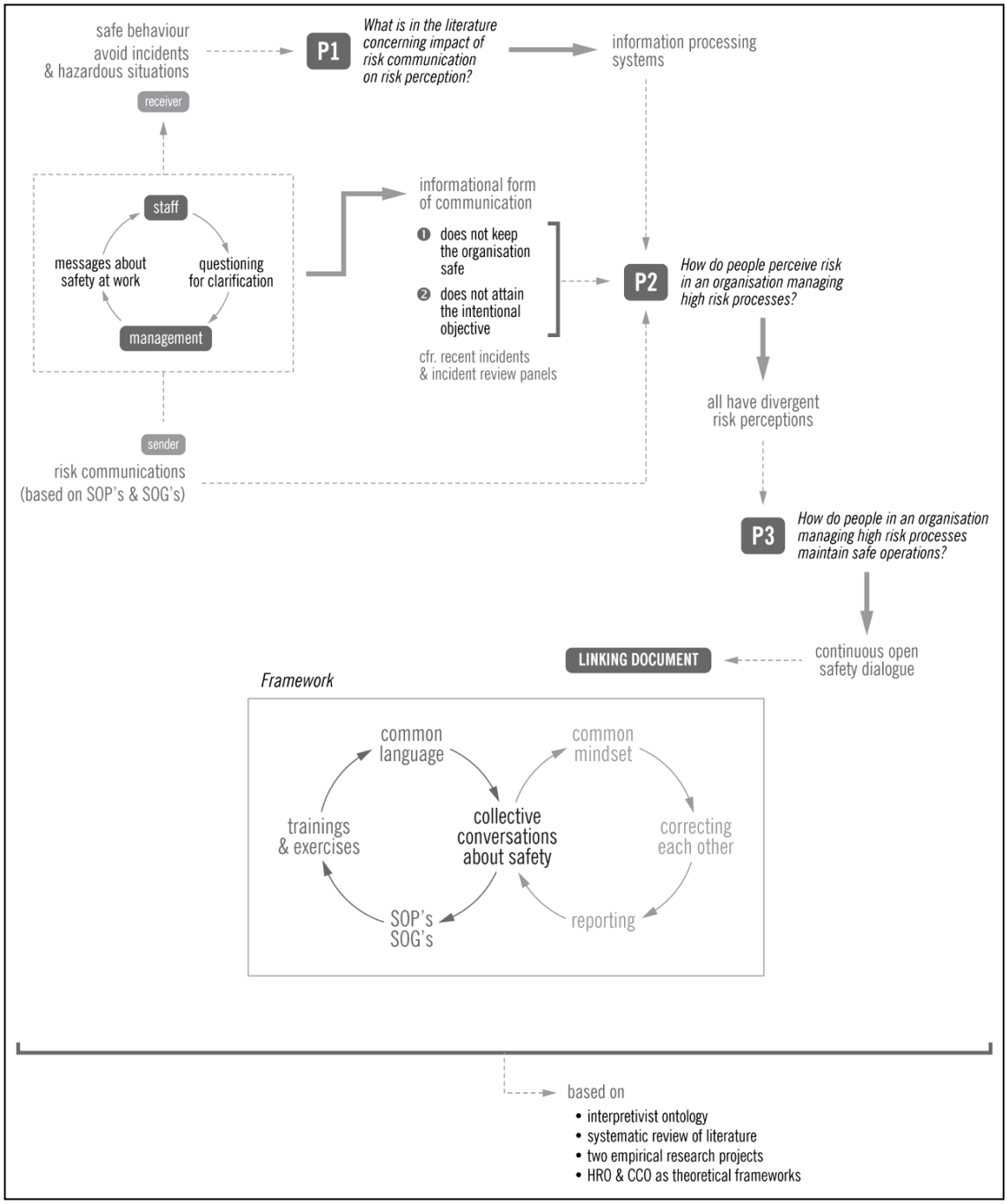

Figure 1-1 Schematic overview of this doctoral research

The thesis is structured into four parts. The Linking Document, which is the first part of the thesis and the current document being read, describes the rationale for this research, the three research projects that were done, the findings of

each of the projects and how that all led to contributions to knowledge and relevant recommendations for practice. Parts II, III and IV of this thesis describe the various research projects in detail: the systematic review of the literature (Part II), and two empirical research projects (Part III and IV).

In this linking document I will frequently refer to specific chapters or sections in Parts II, III and IV of this thesis. This might help the reader to explore some details or specific evidence for certain claims more rigorously.

1.2 Personal motivation for undertaking this doctorate

As a practitioner in the field of risk and crisis communication and management I consult to both major international corporations as well as smaller local enterprises in how to disseminate messages in such a way that they have an impact on employees' safety savvy. In doing so for more than a decade, I have been confronted with two frustrations. The first one had to do with gut feeling, while the second one was based on inappropriate answers from the existing academic research. Over the next paragraphs I will explain both frustrations as the rationale for undertaking this doctoral research.

1.2.1 The problem with gut feeling

In a former era of my professional life, between 1993 and 2000, I had been working as a journalist for the Belgian Radio and Television Broadcasting Company (the BRTN). In this job I covered several small and large crisis situations, such as industrial fires, the bankruptcy of a large shipyard, the recall of medicines, or corruption in a major charity organisation, just to mention a few. Besides a handful of well-executed crisis communication actions, the majority of the organisations with which I worked were not able to communicate in a comprehensive and responsible way when faced by a crisis situation. When I left journalism and became a consultant for predominantly organisations managing high-risk processes, I discovered that none of these organisations had well developed crisis communication plans or even a decent strategy to address a possible crisis situation. I was even more surprised to find out how

these organisations spend millions of Euros on communication and public relations, but when they were confronted with a crisis situation they were ignorant of how to engage with their stakeholders via the media. But, what left me totally flabbergasted was my discovery that the majority of these organisations had neither a plan, nor decent strategy, to prepare their own staff in avoiding crisis situations. Besides a couple of safety procedures to comfort insurance companies and safety auditors, they seemed unaware of how to engage staff in safety behaviour.

And then I came in with advice, mainly based on gut feeling, my experience as a journalist, and logical reasoning. The legitimate question I was asked over and over again was: “And your advice is based on what?” This question was predominantly raised by members of the executive team, rarely by communication managers. The latter mostly agreed on my advice, while the former were reluctant to accept it. This lead to a certain frustration; I was convinced of my recommendations, but I was lacking academic insights and empirical evidence to persuade some of my clients.

1.2.2 The problem with existing academic research

In an attempt to induce those executives among my clientele, I went to HEC Paris and Saïd Business School in Oxford for an executive masters’ course on change management. My rationale for undertaking this programme was that I would find enough academic insights to convince my reluctant clients. The reason for undertaking a masters’ in change management was that my main objective was to change my clients’ approach on risk communication and safety culture. And it did. Solely the fact I was studying at HEC and Saïd Business School gave me an intellectual and competitive advantage among the members of various executive teams. My business was going well, and I was able to set up various challenging projects on risk and crisis communication with multiple clients. As the initial frustration about the unsuitable gut feeling was fading away, a new one came into sight.

The literature I consulted so far was predominantly policy oriented or theoretically based, and the majority of the empirical research I found focussed mainly on how to communicate risks as well as crisis situations to the general public. I found little evidence of good practices on risk communication in organisations, and more specifically in organisations managing high-risk processes. Scholars such as Slovic, Fischhoff, and Morgan (Slovic et al., 2000; Slovic, 2000; Fischhoff and Kadvany, 2011; Morgan et al., 2002) have been examining various types of risk communication based on the psychometric model, and have been doing extremely valuable research in the affect heuristic domain of risks. However, all their research had been based on how civilians[1] react to possible danger or threats, and not on research among employees of hazardous industries. Earlier research by Geller (2001) indicated that employees of hazardous industries have a divergent perception of risks caused by the company they work for than other civilians. Moreover, most of the studies in the field of risk communication examine the affective and cognitive reactions to certain messages (Kasperson et al., 1988; Slovic at al., 2010; Morgan et al., 2002), individuals' information seeking behaviour (Fischhoff et al., 2000), or behavioural intentions (Peters et al., 1997; Burns and Slovic, 2010), but not *how* risk communication – and more specifically what kind of communication – might have an impact on risk aversive intentions. In other words, it is not because employees know the risks, and say that they will take safety measures into account, that they do actually behave in a safe way. This gap in the literature on how communication might foster risk aversive attitudes became the nucleus of my doctoral research. Therefore, the overall question for this doctoral research was: how do organisations that manage high-risk processes have to communicate risks in a way that it affects all employees' risk perceptions and risk savvy, and eventually leads to safe operations?

[1] The term 'civilians' is widely used in the literature on organisational risk and crisis communication. It indicates those persons not belonging to the armed services, emergency services, or the concerned organisation(s).

1.2.3 In search for a positive deviant

It was the late Jerry Sternin, a lecturer at the masters' programme at HEC and Saïd Business School, who unintentionally induced me to dig deeper to find an answer to this business problem. When explaining to him the issue concerning the divide between communication and behaviour, as I observed in businesses, he smiled and said: "Knowledge is not changing behaviour. It is more the other way around." His approach to change behaviour by finding positive deviants in organisations and communities (Pascale and Sternin, 2005; Pascale et al., 2010) inspired and encouraged me to undertake this doctoral research.

Based on my experience as a consultant, I had the feeling that one of my clients, a gas-receiving terminal, could be depicted as a 'positive deviant'. Based on my observations, the way this organisation manages its high-risk processes, and its approach to involve all staff in some sort of safety conversation, was quite unique compared to other clients. That is why I choose this gas-receiving terminal as the object of my empirical research. In a first research project I examined how the terminal staff perceives risks, based on the received communication about the present risks, such as formal communication and safety procedures. In a second empirical research project I examined how the employees of this gas-receiving terminal engage in an ongoing dialogue about safety, and by doing so, constitute the reality of their organisation in such a way that 'doing things in a safe way' becomes second nature. This confirmed my earlier assumption that this company could be described as a positive deviant in the industry: one that has learned to change knowledge by doing things differently.

1.3 DBA structure

To help the reader understand the structure of this document and the specific approach of the research process that underpins this doctoral thesis, it might be helpful to explain the objective and the format of this doctoral thesis.

The research approach for a DBA focuses on topics at the intersection of theory and contemporary business issues (EDBAC, 2013). In that perspective this thesis aims to bridge both the knowledge and the practical gap between risk communication and safety savvy in organisations managing high-risk processes. In terms of the overall design, the Cranfield School of Management prescribes a structure in which a DBA candidate undertakes various research projects.

Initially, a scoping study on the broad field of risk communication and its impact on risk perception were carried out. This study offered an overview of the dominant scholars and current theoretical frameworks in this domain. Building on this, Project 1 (P1) was a systematic review of the literature on the relationship between risk communication and risk perception in complex interactive and tightly coupled organisations. Based on the findings of this review, an empirical research project (Project 2 or P2) was carried out in an organisation managing high-risk processes. This project examined the individual risk perceptions among all employees in this organisation. The final empirical research project (Project 3 or P3) analysed the constitutive role of communication in that particular organisation, and its impact on safety culture.

For more clarity, Table 1-1 offers a brief overview of the review or research questions (RQ) that were raised in the different projects.

Research Question	What type of risk communication has a fundamental impact on risk perception and safety behaviour in organisations managing high-risk processes?
Scoping Study	• RQ: How does risk communication influence the construct of risk perceptions among organisational members? And what is the role of trust in this process?
Project 1	• RQ: What is the relationship between risk perception and risk communication in complex interactive and tightly coupled organisations? • Systematic Review of the literature based on CIMO-logic (26 papers)
Project 2	• RQ: How do people within an organisation perceive the same type of risks? What factors affect the

	perception of these risks? • Repertory Grid and qualitative interviews (28 employees).
Project 3	• RQ: How do people in an organisation managing high-risk processes maintain safe operations? • Social Network Analysis, qualitative interviews, ethnographic and archival research (28 employees)

Table 1-1 Overview of the research projects

In the next chapter of this Linking Document ("Chapter 2 - Summary of the research findings and contributions"), I will elaborate on these various research projects, frame each of the research questions and their link to the overall research objective of this doctoral thesis, and describe the findings. The different approaches for each of the research projects will be discussed as well. Chapter 3 of this Linking Document offers an extensive analysis of the research findings in the context of the overarching theoretical frameworks. This analysis forms the basis of a conceptual framework for a constitutive view of risk communication in organisations managing high-risk processes, while indicating my theoretical contributions to the existing knowledge.

1.4 Definitions of key concepts

For this doctoral thesis, I explored various themes and concepts, which might be helpful to define here. The terms "communication", "risk", "perception", "safety behaviour", "high-reliability organisations", and "complex interactive and tightly coupled" are used in a particular way, and might require clarification to give the reader a better understanding of the content. In Chapter 3 of Part I, I will elaborate extensively on the theoretical frameworks that underpin these terms.

1.4.1 Communication

In this research I focus on organisational communication, which refers to all the communication activity that happens within organisations (Koschmann, 2010). I make a clear distinction between the "the flow of information from one person to another" (Dainton and Zelly, 2011; p. 2), and the interactive process between

two or more persons that create, sustain or manage meaning about an organisational issue (Conrad and Poole, 1998), where I perceive the first one as ‘information’ and the latter one as ‘communication’.

In other words, ‘communication’ might be used to indicate the transfer of information, as well as an interactive process between two or more persons. According to Putnam and Nicotera’s (2010), the latter interpretation might be seen as ‘communication-as-verb’, while the transferring form of communication might be interpreted as ‘communication-as-noun’. In this thesis I will adhere to the ‘communication-as-verb’ view on communication. This view on communication as an interactive process in organisations is embedded in the Process Organisation Theory, as described by Langley and Tsoukas (2010). This will be discussed more broadly in Part IV, paragraph 2.2 (page 232).

1.4.2 Risk

Generally, risk is defined in terms of two dimensions; the first concerns probabilities, the second concerns effects (Breakwell, 2007). Risk refers to the probability or chance individual people, governments and industries take, but this can be linked to positive and negative perceptions. If you ask people what comes to mind when they think about risk, they will most probably refer to health and environmental risks that can have a negative impact on their lives (Leiss, 2004). Effect, the second dimension of risk, is linked to a dominant view in the literature that refers to risk as a calculation of chance every individual, government or industries takes (Breakwell, 2007), and that is associated to both positive and negative outcomes (Leiss, 2004). In this mathematical view, risk can thus be measured, calculated, and controlled. I further elaborate on the term ‘risk’ in Part II, paragraphs 1.3.2 (page 106) and 1.3.5 (page 111).

As I adhere to a more constructionist view on risk, I support Slovic’s argument that human beings invented the concept of risk to cope with the dangers and uncertainties of life (Slovic, 2000). Therefore, risk is more a concept constructed in the mind, perception and emotion of every individual (Slovic, 2000). Consequently the interpretation of risk can vary remarkably, or, as Gurabardhi

and Gutteling argue, the concept of ‘risk’ means different things to different people (Gurabardhi and Gutteling, 2002, p. 428), and in different situations (Ganzach et al., 2008, p. 323).

Based on these insights, the definition that I am using is that risk is socially constructed, and thus both an individual and a collective interpretation of a concept that is based on the chance to lose or gain something, which can individually or collectively trigger associated perceptions that might have an impact on individual, group, institutional or societal level.

1.4.3 Perception

The term “perception” appears in various domains such as sociology, psychology, and philosophy (Mezias and Starbuck, 2003), and is often explained as a phenomenon in both the attribution theory and the cognitive theory (Scott and Marshall, 2005). Attribution theory deals with the rules that most people use when they try to infer the causes of behaviour they observe, and generally attribute their own behaviour to the situation in which they find themselves. The cognitive theory is a major cluster of theories in social psychology that focus on the links between mental processes, such as perception, attitudes or decision-making, and social behaviour. Looking for an appropriate terminology for ‘perception’, different alternatives are mentioned in the literature, such as sensemaking (Weick, 1993), cognitive frameworks (Labianca et al., 2000; Kahneman, 2011), schemas (Labianca et al. 2000), frames (Kahneman and Tversky, 1979), or mental models (Johnson-Laird, 1983). I further elaborate on the term ‘perception’ in Part II, section 1.3.3 (page 107) and Part III, section 2.2 (page 174).

From a constructionist point of view, I am more focused on the dynamic role of perceptions and how that interferes or steers behaviour. Therefore, the definition that I am using is based on Barr and Huff’s (1997) view that perceptions are dynamic processes that lead to decisions and subsequent behaviour, and are largely based on individual and collective schemas, frames,

or mental models and the way people try to fit new information into these existing schemas, frames, or mental models.

1.4.4 Safety behaviour

In the context of risk and safety, accidents never simply occur; they are always seen as caused by someone or something (Hopkins, 2005). This means that someone behaves in such a way that it provokes harm. In an attempt to avoid harm, some form of safety behaviour might avoid the occurrence of an accident, or at least minimise its consequences. According to Antonsen (2009) a definition of safety consists of three elements: 1) it refers to a state or situation where the statistical risk seems to be acceptable or as low as possible, 2) it refers to a feeling of security and control, and 3) it refers to our ability to reduce or eliminate the likelihood of hazardous events occurring (Antonsen, 2009; p. 7). Therefore, the term 'safety behaviour' is interpreted in this research as the way someone acts or conducts himself/herself towards the presence of some hazard or risk, being knowledgeable of the practices needed to diminish or eliminate the potential risks.

1.4.5 High-reliability organisations

High-reliability organisations' (HROs) aim to maintain excellent safety records over a long time period despite operating in high-hazardous environments (Weick and Roberts, 1993; Lekka and Sugden, 2011). The concept of HROs emerged in the 1980s when scholars from the University of California, Berkeley (the so-called 'Berkeley group'), studied how organisations operating with 'high hazard' technologies manage to remain accident-free for impressive lengths of time while meeting high production goals (Denyer et al., 2008; Shrivastava et al., 2009). The basic principles of HRO focus on how organisations can create mindful infrastructures that diminish or even postpone damage produced by unexpected events and impair reliable performance (Weick and Sutcliffe, 2007; p. 2). It argues that organisations can avoid failures by the early tracking of small failures, reluctance to oversimplification, remaining sensitive to operations, maintaining capabilities for resilience, and by deference to

expertise. High-reliability theorists emphasise the human errors school of thought (Reason, 1997), which suggest that failures can be attributed to people.

Karl Weick, who could be seen as the HRO theorist (Antonsen, 2009), clarified: "If there is one flaw with the phrase 'High Reliability Organization', it is that these three words are too static. We'd all be better off if we kept referring to High Reliability Organiz***ing***. Systems, teams, groups, and the best laid plans all unravel. You have to keep redoing them" (USDA, 2004; p. 63 – emphasis in original text). In line with Weick's remark, more recently Hopkins (2007) emphasised on identifying practices and processes that allow organisations to achieve high standards of reliability, rather than identifying criteria that organisations need to achieve to be classified as an HRO. In this research, I will explore the reliability-enhancing practices that are at play in a high-reliability organisation. A more elaborated view on HRO will be explained in Part IV, paragraph 1.3 (pages 228-230).

1.4.6 Complex interactive and tightly coupled

It was Charles Perrow who coined the concept of organisations managing complex interactive and tightly coupled systems (Perrow, 1999; p. 327). Coupling concerns the degree to which certain actions in one part of the system directly affect other parts in the system. In other words, the term "tight coupling" means, "there is no slack or buffer or give between two items. What happens in one directly affects what happens in the other" (Perrow, 1999; p. 90). Interactive complexity refers to how the different parts or components in a system interact. These "connections are not only adjacent, serial ones, but can multiply as other parts or units or subsystems are reached" (Perrow, 1999; p. 75). As a consequence, these complex interactive systems cannot be easily shut down or bypassed and fixed as soon as something is happening. The opposite of a complex interactive system is a linear interactive system. In a linear interactive system "production is carried out through a series or sequence of steps laid out in a line" (Perrow, 1999; p. 72), while the number of parts is irrelevant.

By using a two-by-two dimension of complex/linear interactions and tight/loose coupling systems, four quadrants will appear. The types of organisations that are situated in the ‘complex interactions/tight coupling’ quadrant include nuclear power plants and chemical plants. These are the kind of organisations my research focuses on.

A more elaborated view on Perrow’s (1999) concept of complex interactive and tightly coupled systems, and its distinct difference with HRO, will be explained in Part II, under section 1.3.1 (pages 101-105).

2 SUMMARY OF THE RESEARCH FINDINGS AND CONTRIBUTIONS

2.1 Introduction

In this chapter I will introduce each of the three research projects, and describe the rationale for examining the role each played in relation to the overall research question. A detailed overview of each of the research projects (P1, P2, and P3) can be consulted in Parts II, III, and IV of this doctoral thesis. First, I introduce the scoping study of the literature as an initial point of entrance into the literature on risk communication and risk perception. Subsequently, I describe each of the three research projects that underpin this thesis to provide an initial broader view of the context in which organisations managing high-risk processes operate. Next, I outline the specific approach for addressing the research question and the applied research methods, and offer the key findings of the research. Subsequently, I raise one or more remarks that will lead to the next research project. And finally, I make my claims by indicating my contribution to knowledge.

In a separate chapter (Part I - Chapter 3) I will discuss the research findings in the broader context of the existing literature and applied theories, and propose a conceptual framework for a constitutive view on risk communication in organisations managing high-risk processes.

2.2 Scoping study

The aim of the scoping study was to have a broad multidisciplinary overview of the literature in the domains of risk communication, risk perception, and the role of trust in the common area between both fields of interest. The objective, however, was not to seek final answers to the issue of risk communication's impact on safety behaviour, but rather an attempt to understand how risk communication might influence risk perceptions among organisational members. As recommended by Tranfield and his colleagues (2003), the

conducting of a scoping study prior to a systematic review of the literature is necessary to assess the relevance and size of the literature in the field of research and to delimit the subject area or topic.

This scoping study resulted in an initial overview of basic definitions, models, and theories in the aforementioned domains. However, I discovered that the dominant amount of literature focuses on how civilians and not employees deal with risk perceptions and messages about risks. When it comes to risk communication in organisations, multiple scholars (for example: Douglas and Wildavsky, 1982; Peters et al., 1997; DiBella, 2001; Hudson, 2001, Coan, 2002) indicate communication as an essential tool to create and promote a safety culture. Unfortunately, they do not disclose the communicative mechanisms or the required design for achieving impact on safety behaviour.

On the other hand, the scoping study uncovered how people generally perceive and interpret messages about risks, and how risk experts seldom manage to persuade lay people to taking precautionary measures (Breakwell, 2007; Terpstra et al., 2009) or avoiding risks (Slovic, 2000). Paul Slovic (2000; 2010) and his colleagues (Kasperson et al., 1988; Leiss, 1995; Slovic et al., 2002, Fischhoff and Kadvany, 2011) indicated the difference between the experts' view and the public's view on risks in multiple studies, and demonstrated how among the latter, opinions about various risks might vary based on perceived benefits. This indicates a divide between knowing the risks and the interpretation of those risks, as well as a gap between the individual evaluation of risks among various people. However, these scholars did not indicate an actual change in behaviour based on the interpretation of the risks, but rather the respondents' expressed behavioural intentions.

Therefore, a more profound analysis of the literature was required to investigate the relationship between risk communication and risk perception. To delimit the subject area (Tranfield et al., 2003) the organisations managing high-risk technologies were addressed in a systematic review of the literature.

2.3 Project 1

2.3.1 Context

The objective of the systematic review was to conduct a critical review of a body of literature concerning the relationship between risk communication and risk perception in complex interactive and tightly coupled organisations in order to uncover what was known and unknown about the chosen topic, based on existing theories, empirical research texts and policy texts. Therefore, a closer look at the context, the interventions, and the mechanisms that influence or impact the relationship between risk communication and risk perception in these specific types of organisations was based on the following research question: what is the relationship between risk perception and risk communication in organisations with complex interactive and tightly coupled systems?

2.3.2 Approach

The rationale behind the systematic review was that by examining the literature on risk communication and risk perception in this very delimited area, recommendations could be made to improve practices in risk communication that will ultimately lead to a better safety culture. As the scoping study indicated, the existing research exploring the relationship between risk communication and risk perception predominantly focuses on the way civilians deal with messages about possible danger. Therefore, it was worthwhile to examine the literature that explores this relationship in an organisational context, and more specifically in organisations managing high-risk processes.

In an attempt to examine the literature rigorously, the so-called ‘CIMO-logic’ (Denyer et al., 2008) was applied as a way to synthesise and structure the existing literature. Moreover, Denyer and his colleagues (2008) illustrated this logic for exploring the development of design propositions with earlier published research literature in the field of high-reliability organisations. This CIMO-logic involves a combination of a problematic Context, for which a certain Intervention type produces, through specified generative Mechanisms, the intended

Outcome. The rationale is that by examining Context, Interventions, Mechanisms and Outcomes in the specific domain of risk communication and risk perception in organisations managing high-risk processes, recommendations could be made to improve risk communication practices in these types of organisations. For an extensive view on the rationale applying the CIMO-logic, see Part II, section 2.2 (pages 115-118).

2.3.3 Research method

As the objective of this systematic review was to develop a reliable knowledge base which aims to serve both academic and practitioner communities (Tranfield et al., 2003, p. 220), the aim was to uncover what is known and unknown about the relationship between risk communication and risk perception in complex interactive and tightly coupled organisations based on existing theories, empirical research texts and policy texts. In an attempt to be as inclusive as possible, no difference was made between various ontological or epistemological perspectives in the literature. Although I adhere to an interpretivist perspective, it was important to place my research interests within the wider debate to synthesise different findings of this relationship.

From a total number of 2956 reviewed articles, retrieved from various academic databases, 26 were selected for the systematic review. The selection was based on various criteria, such as source, content, and a severe quality assessment to assure the review was based on “the best-quality evidence” (Tranfield et al., 2003, p. 215). A separate set of quality appraisal criteria based on theory, literature review, method, integration, and contribution, was applied for all research papers that passed the initial assessment criteria (see Part II, section 2.4.4 on pages 126-128).

In an attempt to offer more solution-oriented or prescriptive knowledge to increase the relevance for practice in management science, the various findings in the literature were catalogued according to the four pillars of CIMO (i.e. context, interventions, mechanisms and outcomes). A detailed overview of the

research process is described in Part II of this thesis, under section 2.5 (pages 129-132).

2.3.4 Findings

The findings of the systematic review looked quite fragmented, as we cannot follow the simple reasoning that in order to achieve a specific outcome, we have to apply some kind of magic formula. Although Denyer and his colleagues propose to include "a combination of interventions (I1 … In) that invoke particular generative mechanisms (M1 … Mn) to produce a particular outcome (O) in a specific context (C)" (Denyer et al., 2008, p. 407), still, the interventions are described in an imprecise way. A "comprehensible hierarchical communication" (indicated by Hambach et al., 2011), for example, does not give a precise description of the form or content of this communication.

As both the context (complex interactive and tightly coupled organisations) and the required outcome are known, the practical problem is situated in the interventions that invoke certain mechanisms. In other words, the key question for the systematic review of the literature was how managers have to communicate with their subordinates to provoke risk awareness that will lead to safe or risk aversive behaviour. These interventions and subsequent mechanisms, as revealed by systematically reviewing the literature, include:

- Put safety trainings and learning systems in place, adapt them to the different levels in the organisation (based on knowledge, experience, etc.), champion these trainings, and make sure these actions are not perceived as a "top-down" initiative for the benefit of management to get high scores on safety audits (Grote and Künzler, 2000; Harvey et al., 2001; Specht et al., 2006; Beus, et al., 2010),
- Install a hierarchical communication, based on comprehensible content that resonates with the employees' problem domain familiarity and their beliefs concerning the perceived levels of control or luck (Hambach et al. 2011),

- Add people from throughout the organisation to the decision process. This requires a ‘no blame, no shame’ context where organisational members are respected and valued for their expertise and problem domain familiarity (Beus et al., 2010),
- Introduce a ‘Human Risk Management System’ as it reveals the role social processes play when risks have to be communicated. The context in which employees in complex interactive and tightly coupled organisations find themselves and how they perceive certain risks differ substantially from risk perceptions among civilians. In this, management has influence in supporting people in their sharing of a safety culture (Specht et al., 2006).

On the receivers’ side of the risk communication, it appeared that individuals process information according to an associative or rule-based system (Dillon and Tinsley, 2008). This suggests that risk perception, based on received risk information, is a process that might differ among individuals (for more clarification, see Part II, sections 3.3.3 and 3.3.4 on pages 151-154). This insight was used to build my first empirical research project on. I will explain this in section 2.4 (Project 2).

2.3.5 Contributions

The aim of this systematic was to synthesise and structure existing insights on the relationship between risk communication and risk perception in complex interactive and tightly coupled organisations. Therefore it offered a direction for further research, rather than contributions to knowledge. It suggests how individuals perceive and interpret risk messages according to their information-processing system. Still, this conclusion was based on research that explored how both NASA-employees and survey respondents interpret messages about near misses, and its impact on decision-making under risk (Dillon and Tinsley, 2008). Therefore, a deeper insight in the information-processing systems and subsequent individual risk perceptions among employees in an organisation managing high-risk processes was required.

2.3.6 Remarks

From an interpretivist point of view, I was not expecting to receive a clear-cut answer from the literature on how to communicate risks to have an impact on employees' risk perceptions and risk aversive attitudes. However, I was surprised about the ease with which various authors use the word 'communication' in the context of transferring information from point A to point B. None of the reviewed papers made a critical reflection on the interactive cognitive and social processes that might influence the interpretation of the received information (Rochlin, 1999). This might indicate that my assumption about how risk communication should work - namely not simply as an information tool but as a means to create risk awareness - is wrong. On the other hand, it might suggest that all the reviewed literature simply takes for granted that transferring information is the most optimal way to adjust employees' risk perceptions that ultimately will lead to safe behaviour. In an attempt to question this assumption and to acquire more insights on the effects of communication in these types of organisations, I undertook an empirical research project that focused on individual appreciation of risk.

2.4 Project 2

2.4.1 Situation

The second project investigated the individual risk perceptions of all staff in an onshore gas-receiving terminal (GRT). Along with GRT being a good example of an organisation managing high-risk processes, it is a prime example of an organisation that puts considerable efforts and resources in communicating risks, safety guidelines and procedures. In all, there are over 500 Standard Operating Guidelines (SOGs) and Standard Operating Procedures (SOPs) in use at this GRT. They have safety meetings on a daily basis, multiple safety trainings and crisis simulation exercises on a yearly basis. My assumption was that if this GRT has been doing a good job in communicating the risks, every single employee – or at least the majority – would have a fairly good idea of those risks. This assumption was based on the existing communication models

that all indicate how information might lead to adapted or new insights, knowledge generation, or even behavioural change (see for instance: Shannon and Weaver, 1949; Schramm, 1954; Berlo, 1960; Dozier et al., 1995; Hübner, 2007). Therefore, the research questions that were raised for this empirical project were: do people within a complex interactive and tightly coupled organisation perceive the same type of risks differently? If so, what factors affect the perception of these risks?

2.4.2 Approach

In an attempt to examine individual risk perceptions, and whether these perceptions are in line with the communicated safety guidelines and procedures, I conducted an empirical research project among all employees of an onshore natural gas-receiving terminal in Belgium. This onshore gas terminal promotes a so-called 'Risk Alerting Matrix'. This Alerting Matrix describes four domains (risks related to operations, to personal injuries, to emissions, and to criminal acts) and compels every employee to alert the management team in case something in one of these domains happens. This 'Risk Alerting Matrix' is frequently communicated and used in every training or crisis simulation exercise. My objective was to discover the extent to which the employees' interpretations of risk matched this 'Risk Alerting Matrix'.

2.4.3 Research method

In an attempt to address the research questions, the use of a Repertory Grid technique offered the possibility to uncover different constructs concerning risk as perceived by different individuals in this organisation. Repertory Grid stems from the Personal Construct Theory as proposed by George Kelly (1955). Kelly believed that, in an effort to make sense of their world, human beings individually develop constructions or theories of their world in relation to themselves. These constructions are not fixed, but they change according to new experiences (Kelly, 1955). By applying Repertory Grid-based interviews as a research method, it offered the possibility to make unarticulated or implicit individual constructs of sensemaking explicit (Cassell and Walsh, 2004). The

Repertory Grid technique was not only a powerful tool that helps respondents "articulate their views on complex issues" (Goffin, 2002; p. 199), it is also perceived as a valuable qualitative method for organisational research in the field of risk analysis (Gammack and Stephens, 1994; Cassell and Walsh, 2004) and management research in general (Goffin, 2002). In this case, the Repertory Grid technique was not used to rate participants' responses and to analyse them according to factor analysis, but within an interview setting to obtain qualitative data. It also offered the possibility to tap into the individual's tacit knowledge, and uncovered how each of them made sense of risks in his or her organisation.

A more detailed overview of the research method is described in Part III of this thesis, under the sections 3.1, 3.2, 3.3, and 3.4 (pages 179-185).

2.4.4 Findings

The research design was set up in such a way that all staff, from CEO to maintenance personnel, were asked to indicate the risks they perceive as threatening to normal operations, and those risks with minimal or no impact to operations. The use of the repertory grid technique helped the interviewees to reflect on various aspects of risks and to express more precisely how they interpret those risks. The various risk elements and constructs offered by the interviewees are presented in two tables in Part III, on page 190 (Table 3-4) and page 191 (Table 3-5).

In this research, various parameters were checked to identify plausible factors that influence risk perceptions. From the literature we know that trust in the communicator (Conchie and Burns, 2008; Schoorman et al., 2007), social group relationships (Kasperson et al., 1988), domain familiarity (Gutteling, 1993), and heuristics and biases (Kasperson et al., 1988; Kahneman, 2011) all have an impact on how individuals perceive risk. However, all of these findings are based on research among civilians in relation to governments who are communicating with them, and not with staff in organisations managing high-risk technologies.

It can be argued that trust between the communicator and the receiver of risk information at GRT is relatively high. It is a small group of colleagues (29 in total) who have known each other for a long time: 13.5 years on average, and almost 50 percent of them for 20 years. None of the 28 interviewees mentioned anything indicative of bad intentions or a lack of confidence in the words and actions of their colleagues. In a few cases operation supervisors and maintenance staff did finger-point at each other with regard to neglecting safety rules. It is my interpretation that this was not an expression of distrust, but rather an effort to emphasise how good they themselves knew the risks and safety rules in comparison to others. On the other hand, the question could be raised as to whether this high level of trust at GRT is weakening the organisation from a safety perspective. Earlier findings by Conchie and Donald (2006) who studied the role of trust and distrust in a similar type of organisation, i.e. an offshore gas installation operating on the UK Continental Shelf (Conchie and Donald, 2006) suggest finger pointing can be helpful. They revealed how attitudes of distrust "such as checking and scepticism have a functional role of ensuring a safe work environment" (Conchie and Donald, 2006; p. 1158). In GRT what seemed to emerge was a similar 'healthy' level of distrust, in which individuals checked up on one another and were not afraid of pointing out faults.

Concerning social group relationships and domain familiarity it can be argued that the majority of staff at GRT have a similar educational background (12 undergraduates, 11 with a graduate degree, and two engineers), and a large group share common work experience, as 12 out of 28 were among the first employees who started working at this terminal back in 1992.

When it comes to heuristics, however, there is a significant dissimilarity between the employees who had witnessed a life-threatening crisis situation at their previous job, and those who had not. Almost a quarter of all employees (6 in total) indicated they had experienced a severe crisis situation, such as a fire on board of a ship, an explosion at a chemical plant that killed three blue-collar workers, an emission of a highly toxic product (H2S), or the safety operations at the Herald of Free Enterprise (a ship that capsized on the night of 6 March

1987, moments after leaving the Belgian port of Zeebrugge, killing 193 passengers and crew).

Five of these are operation supervisors, and one is a member of the maintenance team. Together, they mentioned 36 different risk elements, whereas 15 risks are directly linked to their experienced life-threatening situation. An overview of the differences between the different ZPT-employees who experienced a crisis situation and those who did not is presented in Figure 5-1 on page 215.

We see that those who experienced a crisis situation are sensitive to ‘Fires & leaks’ as well as the other employees, but they are much more concerned about ‘Injuries & illness’, ‘Behavioural issues’, and problems with ‘Facilitating systems’. There might be a twofold explanation for this. Firstly, due to their crisis experience they have some kind of knowledge of how systems might break down, quite often by wrong manipulation and how this has an impact on personal injuries (4 out of 6 interviewees who witnessed a severe crisis situation at a previous job attributed these incidents to behavioural issues when dealing with systems that eventually lead to personal injuries). Secondly, it might be argued that these persons have a fairly good knowledge of the company’s procedures. As earlier indicated, these procedures predominantly focus on how to prevent systems’ failures and personal injuries, and thus give clear guidelines on safety behaviour.

Comparing the constructs that were offered by all the interviewees and those who experienced a crisis situation, the differences are less explicit. The employees who experienced a life-threatening crisis situation predominantly talk about ‘Human factors’ and ‘Plant & process related issues’, and less about ‘Tangible & non-tangible damage’ and ‘Organisational relation structures’. Moreover, the six employees who experienced a crisis situation came up with more constructs (56 in total, an average of 9,33 per person) than their colleagues (184 constructs in total, an average of 8,36 per person). (For more details see Figure 5-2 on page 216).

This indicates that the employees who had experienced a life-threatening crisis situation at a previous job have a different view of the actual risks in the organisation. Furthermore, these employees also acknowledge the importance of crisis experiences in their attitude versus risk at work. This is apparent in the following quotes:

"That's the big disadvantage here; we don't face problems. Because nothing serious is happening here, no one has a sound knowledge of all the possible dangers on this plant. You do learn from your mistakes. But here, we don't learn anything at all." (Interviewee #26)

There is evidence in the field of fire-fighters' trainings that by increasing the reality level of the exercises, for instance by experiencing a real 'flashover' (this is when the majority of an exposed surface in a space is heated to its auto-ignition temperature and emits flammable gases. Flashovers normally occur at 500 °C) in a simulator, fire-fighters' practical knowledge and risk awareness will increase massively (Daniels, 2006; Baumann et al., 2011). Therefore it could be argued that heuristics of real life-threatening situations do indeed have an impact on employees' risk perception.

Summarised, the results indicated that every single person in this GRT has divergent interpretations of the present risks. Although the majority of the employees referred to risks that appear in the 'Risk Alerting Matrix', and thus risks that GRT indicates as crucial in the sense of bringing the operations and likely the existence of the company in danger, no two individuals indicated exactly the same risks. Furthermore, it revealed that those employees occupying different roles in the organisation have very different perceptions of workplace risks. These differences are affected by various factors such as the level of experience and tacit knowledge. However, previous real life threatening experiences appeared to be a dominant predictor for a broader and more divergent view on the present risks. These findings suggest that the transfer of information concerning organisational risks does not achieve the initial aim of the risk communication, namely creating a common ground of knowledge concerning present risks in the organisation. Therefore, it refuted my earlier

assumption concerning the effect of risk communication, as it indicated how the transfer of risk information in an organisation managing high-risk processes does not lead to generic risk perceptions among the staff.

2.4.5 Contributions

This empirical research offered contributions to both practice and knowledge. On a practical level, the repertory grid method for discussing safety issues and risks was perceived by the management team of this gas-receiving terminal as a valuable tool for internal use. However, I am not aware of the effective implementation of the repertory grid technique in this company yet. In a session I held after finishing P2, in which I elucidated the findings of my research, two members of the management team indicated that the use of the repertory gird technique might offer the possibility to align various views concerning safety, management issues, and other daily topics of discussion, as it helps employees to articulate their ideas more clearly.

On a theoretical level, this research contested the dominant way of looking at organisational communication (Dozier et al., 1995) that is based on 'the mathematical model of communication' (Shannon and Weaver, 1949). This mathematical model is based on a mere transfer of information from a sender to one or more receivers. The gas-receiving terminal that was the focus of my research applied this model as well to disseminate the more than 500 safety procedures and guidelines. However, this research demonstrates that people do not "receive" information, but rather interpret it in their mental framework. This claim can be supported by the data of P2 indicating how the majority of the interviewees referred to descriptions of risks they experienced previously as life threatening (those who experienced a real life crisis situation), harmful (as they once had a minor injury), unhealthy (as one of their close colleagues was suffering from cancer), malicious (as some of the employees just went through a realistic simulation training of a criminal act), or systemic (such as a break-down of the computer system). I will elaborate further on this contribution in the next chapter of this linking document (Part I - Chapter 3, pages 57-83). Finally,

it can be argued that besides the divergent risk perceptions among the interviewees at this gas receiving terminal, the method of Repertory Grid uncovered how employees who experienced a crisis situation came up with more constructs than their colleagues.

2.4.6 Remarks

Concluding that communication, in the sense of transferring information from management to employees, has no effect at all on the employees' risk perceptions might be a bridge too far. Although all the staff of this gas-receiving terminal mentioned different risks, the most alluded to risks can be found in the domain of risks related to operations. That is no surprise as this domain is directly linked to the gas-receiving terminal's core business. However, it might be argued that the informational approach of communication (Koschmann, 2012) that is practised in this organisation is not fulfilling its initial aim: creating a common mindset about the actual risks.

On the other hand, it raises the question of how this gas terminal has managed to coordinate safe operations over more than 20 years, while every single employee holds divergent interpretations of the actual risks in this gas terminal. This question formed the basis for the third and final research project.

2.5 Project 3

2.5.1 Context

The previous empirical research project (P2) indicated how every single individual in an onshore gas terminal holds divergent interpretations of the present risks. This suggests that transmitting information through various forms of communication fails to create a uniform perceived interpretation of the potential risks in the organisation. Given that, these variable risk perceptions might actually endanger safe operations, as every individual perceives potential danger differently. On the other hand, the gas terminal that was the subject of this empirical research has been operating accident-free for more than twenty

years, which is at odds with the average number of fatal accident rates in onshore gas companies (OGP, 2012; DNV, 2013). Therefore it might be argued that this gas-receiving terminal was relying on pure luck, or that it has achieved some form of coordinated safety behaviour. In an attempt to uncover what exactly happens in this organisation, and how it has managed safe operations for over more than two decades, this research project explored the interactive processes between all the staff.

2.5.2 Approach

For this research, the work on high reliability organisations (Weick and Sutcliffe, 2007) was taken as the main theoretical source (for more details, see Part IV, section 1.3 on pages 228-230). Other theoretical sources that underpinned this research were the work on Process Organisation Studies (Langley and Tsoukas, 2010), and on Communication Constitutes Organisations (Putnam and Nicotera, 2010) (for more details, see Part IV, sections 2.2 and 2.3 on pages 232-234). All these theoretical sources are rooted in an interpretivist epistemology.

In the next chapter of this linking document (see sections 3.3 and 3.4 on pages 61-66) I will elaborate on these theoretical sources.

2.5.3 Research methods

As my research project aimed to uncover the networks of communicative acts about risks and safety, the research was designed to indicate how these interactions play out, who is interacting with whom, and how it is unfolding (for more details, see Part IV, section 3.4 on pages 238-244). According to Blaschke and his colleagues (2012), social network analysis is the most suitable research method for examining this constitutive character of communication (see Part IV, section 3.1 on pages 235-236). Besides the data acquired through social network analysis (SNA), three other sets of data were analysed: 1) qualitative data from the semi-structured interviews, 2) ethnographical data and 3) archival data (for more details, see Part IV, section 3.4 on pages 238-239).

The research explored four dimensions, three were based on the theoretical HRO framework, and one was based on findings of my previous research project (P2). The three HRO dimensions, as theorised by Weick and Sutcliffe (2007), were anticipation, containment, and mindful organising. The one linked to my previous research examined the impact of social relationships on reporting safety issues. An overview of the various questions, linked to the two HRO dimensions and the social relationships, which were raised and analysed in the social network analysis, can be found in Part IV, section 4.1, Table 4-1 on page 247).

The fourth dimension, mindful organising (Weick and Sutcliffe, 2007), was analysed through coding of the interview data. More details concerning the findings and how they were analysed can be found in Part IV, section 4.7 on pages 265-269.

2.5.4 Findings

The analysis of all the SNA, the qualitative interviews, and the ethnographical data, indicated how in this organisation literally everyone is talking to everyone about safety. Figure 2-1 (on page 50) offers an almost unique illustration of how the entire organisation has an ongoing conversation about safety and potential risks.

Everyone in this organisation refers to others as an initiator of safety conversations, and at the same time everyone is also indicated as an initiator of these types of conversations. A detailed overview of the findings that support how everyone talks to everyone about safety in this organisation is presented in Part IV, section 4.4.2 on pages 253-255.

Data indicated that these safety conversations are rooted in the safety procedures and guidelines, which in turn are the result of active conversations about how to improve safety related issues by refining existing procedures and guidelines (see Part IV, section 4.4.1 on page 251). The management team has a specific supporting role in the mindful organising processes (see Part IV,

section 4.8 on pages 269-270). While they have created a mental space for these types of conversations - they call it “the open safety dialogue” - the data indicated that the management team has a leading role in feeding, conducting and supporting these conversations (see Part IV, section 4.4.3 on pages 255-256). Moreover, this open safety dialogue creates a certain culture in which employees feel comfortable to approach and correct each other when observing unsafe situations. More than 82 percent (23 out of 28 employees) indicated they would immediately address the person who is creating an unsafe situation (see Part IV, page 251). The data also indicated that there was no correlation between social relationships and safety reporting. In other words, even people with longstanding friendships, indicated they will address and correct their friends if they detect unsafe actions.

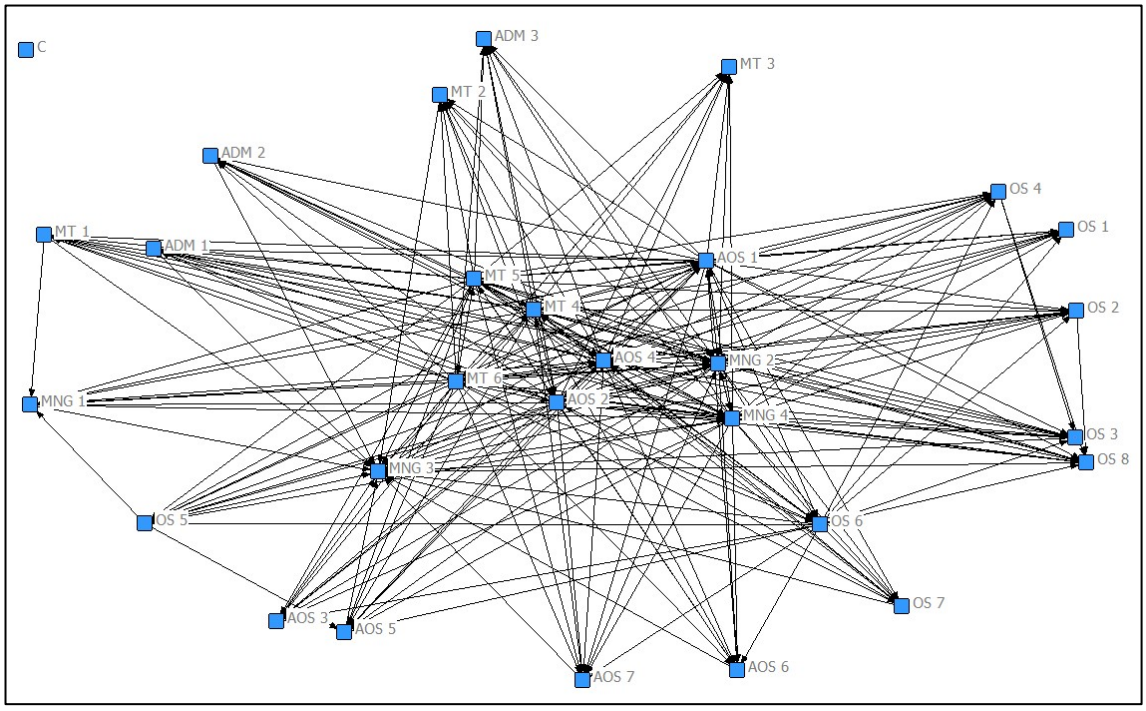

Figure 2-1 Social network map, indicating employees’ engagement in safety conversations

With regard to the overarching HRO principle of mindful organising, the interview data showed how all the attitudes and prerequisites for creating a safety culture are present among the staff, and how standardised processes are constantly discussed, aligned, and evaluated prior to starting a job. To achieve

high reliability, Weick and Sutcliffe (2007) indicate 'mindful organising' as an overarching prerequisite. It is about a set of attitudes, such as "human alertness, experience, skill, deference, communication, paradoxical action, boldness, and caution" (Weick et al., 1999; p. 105-106), that aim to foresee the unforeseeable. This attitude of mindful organising encourages organisational members to detect flaws or minor mistakes that they may have missed before, and in this way it prevents an organisation from unwanted events. Hence, it describes a corporate culture in which safety values and expectations about risk averse behaviour and early (mindful) detections of flows are encouraged. In an attempt to instil and maintain such a corporate culture, Weick and Sutcliffe denote five elements that have to be put in place as a prerequisite to produce a culture of mindful organising. These elements are: thinking differently about 1) success, 2) simplification, 3) strategy, 4) plans, and 5) authority (Weick and Sutcliffe, 2007; p. 148).

In an attempt to gauge ZPT's ability for mindful organising, all the interviews and ethnographical data were analysed and coded according to two sets of elements: the prerequisites for creating a culture of mindful organising (Weick and Sutcliffe, 2007), and attitudes to foresee the unforeseeable (Weick et al., 1999). In the next sections I will discuss each set of elements separately. A complete overview of all the data can be consulted on page 76, Table 3-1.

2.5.4.1 Attitudes

It might be argued that foreseeing something unforeseeable (Weick et al., 1999) is an almost impossible task, as the latter is intrinsically linked to something that is not possible to anticipate or predict. Therefore, Weick and his colleagues indicate a set of attitudes (human alertness, experience, skill, deference, communication, paradoxical action, boldness, and caution) which, when they are present among staff, might provide warning signs of possible flaws or danger (Weick et al., 1999).

The interview data of this second empirical research project (P3) indicates how all these attitudes are present among staff, predominantly in combined sets. An

example of this is when someone recalls how he or she interacted with a colleague concerning something that involves deference to the other person's expertise, based on a concept of being cautious in operations, and alertness. The following example illustrates how an Adjunct Operation Supervisor mentions communication, deference, alertness and caution in one single quote: *"In fact, I do talk to everyone about safety. When I see someone from maintenance who might be involved in my project, I will definitely approach him about certain issues that might pop up. These guys know all the ins and outs of our plant, better than anyone else. Recently, a couple of contractors had to do a repair job on the metering installation. It was a rainy day, and I was worried about how to avoid water in the installation. I discussed this with my colleague and warned the on-call maintenance guy."*

The most frequently mentioned elements are communication and experience. As already indicated in the findings of the social network analysis, the threshold level among employees for approaching each other to indicate potential dangerous behaviour of risks is very low. One member of the maintenance staff articulated it in this way: *"When I see someone doing something stupid, I will immediately say 'you're not doing a good job, pal!' This will be reported anyway. And if it concerns serious misconduct, I will immediately inform our HSEQ manager; to say 'that guy over there is definitely not doing it right'. In my view, that's what needs to be done. Irrespective of who's doing something stupid."*

Formal communication in terms of alignment concerning the safe execution of jobs is also mentioned quite often. It illustrates how standardised processes are constantly discussed, aligned, and evaluated prior to the start of a job, and thus clearly indicates a mindful attitude. *"Every morning, the COO passes by, just to check if we are expecting anything special that day. The same story with our CTO. And our morning meeting of course where we discuss various issues," an Adjunct Operation Supervisor recalled*. One operation supervisor added: *"A recurring topic at the morning meetings is the question how we might improve safety. Quite often Jan, our HSEQ manager, starts this conversation by*

introducing a randomly chosen issue. It also happens that a minor incident becomes the theme for an in-depth discussion on how to improve things."

The element of 'experience' is predominantly linked to know-how of the job, such as *"I will explain to them what I experienced, and how I solved it, more in the sense of making sure they will not fall into the same trap as I once did"* (according to an Operation Supervisor). Still, experience is also often linked to insights and knowledge acquired in trainings and subsequently applied to the job: *"Trainings and exercises clearly indicate the [safety] direction we're aiming for",* and *"We all have more or less the same level of knowledge, based on the trainings we all followed here in the company. But luckily, everyone has different skills. Both, skills and knowledge, give us all the required experiences to manage this plant safely"* (mentioned by two different Maintenance staff members).

2.5.4.2 Culture

When it comes to thinking differently about success, simplification, strategy, plans, and authority (Weick and Sutcliffe, 2007), it is remarkable how many employees at ZPT mention authority (21 out of 28) and strategy (18 out of 28). In almost all the interviews, both aforementioned elements are linked to management actions, initiatives or vision. The following quotes support this: *"there is no blaming culture in this company"* (a manager), *"We don't have a 'normal' hierarchy in this organisation; new entrees can learn as much from employees who have been working here for more than fifteen years, and vice versa. You will find that attitude in our management team as well"* (an operation supervisor), and *"Our management team made it very clear that safety is everyone's responsibility"* (maintenance labourer). This last quote is confirmed by *"We are all safety officers in this organisation"* (an adjunct operation supervisor).

It might be argued that the elements for producing a culture of mindful organising, as described by Weick and Sutcliffe (2007), are predominantly linked to management actions. Envisioning success, simplifying processes,

adapting and implementing a strategy, making organisational plans, and exerting authority, are all typical leadership or management tasks. That might explain why predominantly members of the management team referred to these elements to produce a culture of mindful organising (see Table 3-2).

A concluding consideration is linked to Antonsen's (2009) connotation of "a 'good' safety climate" (p. 17). Antonsen argues that a common mindset about safety can only flourish in a "'good' safety climate […] where managers at all levels are highly committed to safety; where the workforces express satisfaction with and adherence to the organisation's safety system; where everyone is risk averse; where there is no pressure towards maximising profits at the expense of safety and where operators as well as managers are highly qualified and competent" (Antonsen, 2009; p. 17). In various interviews, both in P2 and P3, several employees quoted the company's unofficial catchphrase "time and money are no excuses for executing a safe job", while underlining the management team's dedication to safety no matter what. That clearly supports Antonsen's description of a safety climate.

2.5.5 Contributions

This research project (P3) offered two theoretical contributions. First, it empirically confirmed Weick and Roberts' concept of 'heedful interrelations' (1993) in an organisation managing high-risk processes. Weick and Roberts describe heedful interrelations as a collective investment in "time and effort to organise for controlled information processing, mindful attention, and heedful action" (Weick and Roberts, 1993, p. 357). The findings of my P3 indicate how these heedful interrelations among all staff lead to a mindful way of dealing with the present risks. When Weick and Roberts (1993) introduced the concept of 'heedful interrelations', their arguments were based on extensive qualitative research in military organisations (more specifically nuclear-powered aircraft carriers, see: Roberts et al., 1994). However, the focus of their research was not coordinated behaviour, it was based more on the cognitive factors that affect the decision processes. Therefore, Weick and Roberts did not indicate

how these ‘heedful interrelations’ lead to collective conversations concerning safety in organisations managing high risks. They demonstrate how pilots of aircraft carriers develop mental processes that allow them to make the right decisions in milliseconds, based on controlled information processing, mindful attention and heedful action. Instead, my research shows how heedful interrelations (Weick and Robberts, 1993) – or open safety dialogues (see Part IV, pages 245-246) - encourage employees to engage in an organisation-wide conversation (see Part IV, pages 253-255) on safety and risk avoiding initiatives (see Part IV, pages 251-253).

Secondly, this research is the first of its kind that empirically explores the role of Communication Constitutes Organisations (CCO) in an organisation managing high-risk processes (see Part IV, section 6.4, pages 277-278). A couple of similar studies have been published or presented, but all with a different approach concerning the type of organisation (such as fire fighters, terrorist organisations, etc.) or theoretical approach (such as a situational boundary-making approach, analysis of critical incident narratives, or workgroup-level safety climate research). Moreover, none of these studies indicate how CCO plays an active role in maintaining safe operations.

2.5.6 Remarks

In a recently published study, Lekka and Sugden (2011) argue that although the HRO characteristics are particularly important for organisations operating in high-hazard industries, “previous research has predominantly focused on non-profit organisations” (Lekka and Sugden, 2011; p. 443) such as schools or hospitals. Thus, little research has examined commercial organisations. In that perspective, this empirical research might offer valuable contributions to the already existing HRO literature, and opens new avenues for further research. I will elaborate further on these two subjects (contributions and further research) in the following chapters of this linking document.

3 DISCUSSION OF RESEARCH FINDINGS AND CONCEPTUAL FRAMEWORK

3.1 Introduction

In this chapter I will propose a conceptual framework for creating a constitutive view on risk communication in organisations managing high-risk processes. This framework is based on the findings of my three research projects and supported by the literature in the fields of HRO and CCO. It describes a process in which conversations about safety related issues create a common mindset for enhancing safe operations within a complex interactive and tightly coupled organisation.

In referring to my data in the next sections, the following abbreviations are used:

- ADM: member of the administration team
- AOS: member of the adjunct operations supervising team
- MNG: member of the management team
- MT: member of the maintenance team
- OS: member of the operations supervising team

The numbers behind the abbreviations indicate a person in that specific team. For confidentiality reasons, the names have been changed. Throughout this chapter I have used italics for a specific purpose. This is to signify that interviewees have expressed quotes or words that I have italicised.

Before clarifying this conceptual framework, I will first explain how risk communication is traditionally perceived and implemented in most organisations, and why this fails to achieve its main objective, namely creating safe behaviour. Although I did not study the behavioural effects of communication, it might be argued that organisational communication aims to create some kind of action (Shockley-Zalabak, 2009) or a “desired conduct” (Shannon and Weaver, 1949; p. 5) at the receiver’s level. Therefore, I will focus on the type of communication that creates a safety culture in which safe

behaviour eventually becomes an integral part of that culture, rather than a consequence of receiving information.

3.2 The issue with communication

Currently, the majority of management books in the field of risk management or business continuity management proclaim communication to be key in creating awareness and disseminate data about the potential risks that might endanger an organisation (see for instance: Reason, 1997; Groeneweg, 2002; Morgan et al., 2002; Breakwell, 2007; Elliott et al., 2010). The reasoning behind this type of communication, which is based on a transfer of information, is that when people know how and what to do, they will act accordingly. However, this view on communication is based on the so-called Shannon-Weaver Communication Model (Shannon and Weaver, 1949). This linear transmission model of information is based on a mathematical theory of communication that was presented by Claude Shannon in 1948 in the Bell System Technical Journal, aimed at improving the use of communication between a sender and a receiver over a telephone line. One year later, Shannon and his colleague Warren Weaver published the book *The Mathematical Theory of Communication* (Shannon and Weaver, 1949), based on Shannon's initial article in the Bell System Technical Journal, albeit applied to communicative practices in general. To date, this theory is an integral part of the curriculum in many masters' programmes in communication science around the globe, and is generally accepted as the most prominent communication theory (Miller, 2003). Multiple communication theorists, such as Schramm (1954), Berlo (1960), Dozier et al. (1995), and Hübner (2007), just to mention a few, have built their theories on the basic pillars of this Mathematical Theory of Communication (Shannon and Weaver, 1949).

The issue with this mathematical model of communication is that it focuses on how information might be transferred between sender and receiver in the most optimal and clear way, while avoiding technical, semantic and effectiveness problems (Shannon and Weaver, 1949). Technical has to do with the means of

communication (such as text, radio, telephonic transmission, etc.), the semantic with the interpretation of meaning on the receiver's side, and the effectiveness is "concerned with the success with which the meaning conveyed to the receiver leads to the desired conduct on his part" (Shannon and Weaver, 1949; p. 5). My main argument against this mathematical model of communication is that although a single individual might create and transfer information, he or she cannot steer the understanding, and thus control the aimed effectiveness of the communication as described by Shannon and Weaver. The results of my first empirical research project (Project 2) illustrate how messages about the present risks do not lead to the same understanding of risks among all employees.

When we translate this mathematical model of communication to risk communication in organisations managing high-risk processes, we distinguish a sender (in this case the management team, supported by the communication department), a receiver (in this case all organisational members), a message (in this case about the risks and how to work safely), a communication channel (this might be a meeting, posters, safety video, written procedures, and the like), and a feedback mechanism in which employees might turn back to the sender of the communication for more clarification concerning the given information. This process, based on the so-called Shannon-Weaver Communication Model (Shannon and Weaver, 1949) is presented in Figure 3-1.

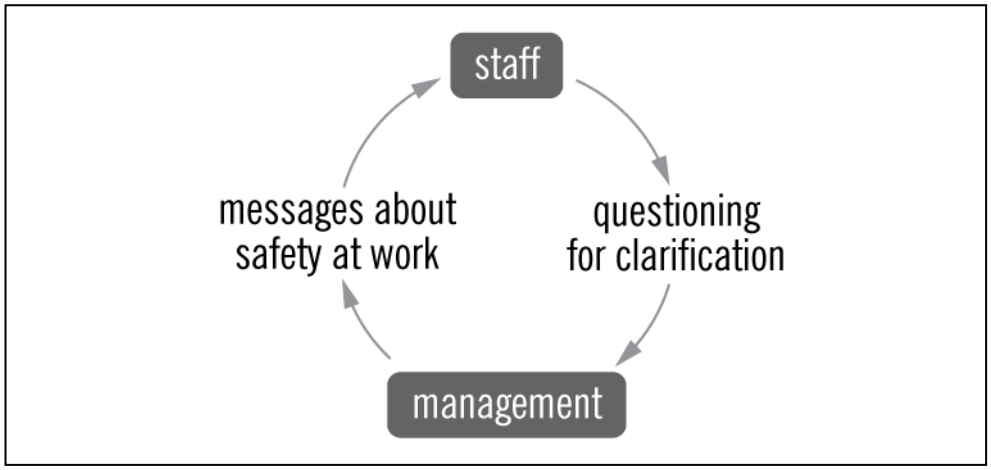

Figure 3-1 Risk communication process based on the Mathematical Model of Communication (Shannon and Weaver, 1949)

Contrary to this model, findings of my P2 and P3 indicate that individuals do not 'receive' information; they interpret information based on experiences (P2 showed how employees with real life-threatening crisis experiences had a broader view of the present risks, see Part III, section 5.2.2 on page 213) and interpersonal and collective conversations. Over the next sections I will demonstrate, based on the data of P2 and P3, how literally everyone in the organisation has conversations about safety issues with everyone else, and how through these conversations they 'made sense' of what needed to be done from a safety perspective in the organisation. By doing so, these employees construct a certain meaning based on the perceived messages (van Woerkum, 2011). Interpretation of information is thus a mental process in which we create meaning based on one or more perceived messages, but it does not necessarily lead to the desired "conduct" (Shannon and Weaver, 1949; p. 5). This process has its origin in social and psychic systems, and is based on communicative elements (Luhmann, 1995). According to Luhmann, communication is an emergent reality that arises from the interactions between different individuals and through a combined synthesis of three different selections: "selection of information, selection of utterance of this information, and a selective understanding or misunderstanding of this utterance and its information" (Luhmann, 1992; p. 252). In other words, it takes at least two individuals to co-produce the understanding of utterance of information (Seidl, 2009).

Therefore, it might be argued that although an organisation applies the five principles of HRO, when it predominantly relies on this mathematical model for communicating risks, it will not achieve the overarching prerequisite of 'mindful organising'. According to Weick and Sutcliffe (2007), mindful organising is a different mindset that creates a corporate culture in which safety values and expectations about risk aversive behaviour and early detections of flaws are encouraged. This requires understanding of utterance of information (Seidl, 2009), which is not achieved by merely transferring information (Koschmann, 2013).

Linking back to the gas-receiving terminal I examined for this doctoral research, I looked at how employees made sense of the present risks in their organisation and how they interact with each other in terms of safety. However, I did not investigate how they moved from sensemaking to action. Yet, it might be argued that this company's longstanding safety records (see: "2.5.1 Context") are not solely based on pure luck, but on a corporate culture that values safety and risk aversive attitudes.

Over the next sections I will elaborate on this by presenting a conceptual framework which indicates how conversations about safety related issues might constitute a culture that enhances safe operations in an organisation managing high-risk processes. As this framework is based on a concept of how conversations constitute a collective attitude towards the present risks in the organisation, I will first discuss two theoretical domains in the existing literature; on CCO (Communication Constitutes Organisations) and on coordinated behaviour. Subsequently (see: "3.5 Towards a conceptual framework"), I will introduce the various elements of the conceptual framework while supporting every step to both the theoretical elements, as well to the data retrieved from my research projects.

3.3 Communication that constitutes organisations

3.3.1 Theoretical background

In the domain of Process Organisation Studies communication is perceived as actively creating the social reality of an organisation, in other words 'Communication Constitutes Organisations' or 'CCO' (for an overview on the CCO perspective in organisation studies, see: Blaschke et al, 2012). CCO draws on the view of organisations as "networks of conversations" (Ford, 1999; p. 485), where through "telephone calls, meetings, planning sessions, sales talks, and corridor conversations […] people inform, amuse, update, gossip, review, reassess, reason, instruct, revise, argue, debate, contest, and actually constitute the moments, myths and, through time, the very structuring of the organization" (Boden, 1994, p.6). From this point of view, communication is

perceived as central to the social construction of the organisation's reality (Hübner, 2007) as it takes an active stance in mutual interactive processes.

CCO distinctively differs from the 'informational view of communication' as proposed in the earlier explained mathematical model of communication (Shannon and Weaver, 1949), whereas in the latter the focus is on expression and the process is a straightforward transfer of information (Koschmann, 2013) within an organisation. CCO, on the other hand, perceives organisations "as" communication, opposed to communication that happens "within" organisations. Instead of viewing communication as merely the transfer of information, this approach considers communication as the fundamental process that shapes social reality which is a rather complex process of continually creating and negotiating the meanings and interpretations that shape our lives (Koschmann, 2013). Therefore, this approach is more a 'constitutive view of communication' as it coordinates organisational members' interpretation of their working environment, the way they act in it, as well as the organisation itself (Cooren, 2012).

Therefore, the insight that this CCO theory brings to my particular phenomenon is that employees do in fact have conversations about multiple topics that concern the organisation. One of the topics is about safety and how to do things in a safe or safer way. These conversations might be influenced by a formal transfer of information (for instance the dissemination of guidelines and procedures), but also by common experiences on the shop floor, trainings and exercises, or stories they get from friends and colleagues in other plants.

However, it is too big a leap to conclude that all conversations solely concern safety issues. Employees discuss other things as well, such as football, beer, or what was on the television last night. Moreover, it is too simplistic to accept that only shared conversations that shape social reality will lead to collective action. The question can be raised what facilitates the fact these conversations are about safety, and not just about social or private activities? Therefore, in one of the following sections (see: 3.4 Understanding coordinated behaviour) I will look at the concept of 'activity coordination' (McPhee and Zaug, 2001) in an attempt

to link CCO to collective coordinated behaviour in organisations managing high-risk processes. First, I will describe observed examples of how communication constitutes the organisation. These observations are taken from my ethnographical data at GRT.

3.3.2 Observed micro processes

Based on ethnographical data collected over the two empirical research projects at GRT, this section will present two observed examples of micro processes that illustrate how communication constitutes this particular organisation.

Besides trainings, the dissemination of safety procedures and guidelines, and formal safety reporting, I witnessed on a daily basis multiple informal conversations about safety and potential risks among staff members. In this rather small organisation, I observed that everyone seems to talk to everyone. On several days I witnessed how staff sat at a large round table over lunch, having a chat about various topics concerning safety. On April 2012, five employees (the CEO, two maintenance labourers, an operation supervisor, and the receptionist), were discussing the new safety fence that was under construction. This informal conversation started with the receptionist questioning why so much money had been invested in a high-tech safety fence. And why, one of the maintenance labourers added, did it have to be built by a British construction firm? The CEO made a joke saying the Brits had more experience with cunning terrorists than Belgians do. The operation supervisor then explained the rationale from Head Quarters to improve the protection measures on each site, according to European and American safety requirements. What followed was a vivid conversation about the why of safety, the precautionary measures each organisation dealing with sensitive products has to take, and their moral and public responsibility regarding safety for both own employees and third parties. Everyone at the table got involved in this discussion. Examples of previous malicious attacks on other production plants were described and translated to the GRT situation. It was impressive to see

how they all slowly but steadily reached a common understanding of the need for a solid safety fence. Two weeks later, when I was doing my repertory grid interviews, other co-workers than those who attended this conversation over lunch, mentioned exactly the same examples and a similar rationale arose for protecting the terminal against potential terrorist threats.

A second micro process example that illustrates the communicative constitution of the gas-receiving terminal that was the subject of my empirical research, was a conversation at a morning meeting of the operational and maintenance staff in February 2013. After reviewing the various subjects of the previous day and the work orders for that day, the HSEQ manager (Health, Safety, Environment, and Quality) moved the conversation into another direction. “Based on an anomaly we recently experienced at the second process train, I gave the procedure for maintaining these trains a closer look,” he said. “May I suggest we take a couple of minutes to reflect on this?” What happened next was an in-depth technical discussion among all present on the applicability of this procedure. At the end of the meeting all agreed to give this a further thought. During the day, I witnessed two employees (a maintenance worker and a deputy operation supervisor) sitting together in a meeting room, with that particular procedure in print on the table, and a white board full of colourful flowcharts. Two days later I happened to pick up a conversation in the lunch area between various employees and the HSEQ manager concerning this particular procedure and viable options for improvement.

Both examples illustrate how certain topics concerning safety are food for in-depth discussions outside official meetings, and how the interactions between various actors constitute the very reality of the organisation and the way it deals with safety. These examples typified the kind of conversations and interactions about safety I witnessed during my three-year engagement with GRT.

3.4 Understanding coordinated behaviour

Charles Perrow, who has done seminal work in the field of risk management in tightly coupled and complex interactive organisations (Perrow, 1999), argues

that in environments where exceptions and problems frequently arise, a kind of coordinated adjustment is required (Perrow, 1967). McPhee and Zaug (2001) contend that this process of adjusting and solving immediate problems requires a distinct type of communication, namely 'activity coordination'. This is when organisational members are "interacting to align or adjust local work activities" (McPhee and Zaug, 2001; 587). In a later paper, McPhee and Zaug (2009) link this activity coordination to Mintzberg's coordination process of mutual adjustment. That is to say members mutually adjust, and by doing so they coordinate their activity "not just on related tasks but within a common social unit with an existence that goes beyond the work interdependence itself" (McPhee and Zaug, 2009; p. 39).

According to Mintzberg (1993) collective behaviour in organisations can be achieved through five coordinating mechanisms: mutual adjustment, direct supervision, standardisation of work processes, of outputs, and of input skills. He argues that mutual adjustment is based on achieving coordination by the simple process of informal communication, and "the need to maintain a small face-to-face work group to encourage mutual adjustment when the work is complex and interdependent" (Mintzberg, 1993; p. 69).

In an attempt to link Mintzberg's concept of mutual adjustment to the CCO perspective, McPhee and Zaug's (2009) refer to Fairhurst and Putnam's (2004) work on discourse and organisations. In their framework for examining different perspectives on CCO, Fairhurst and Putnam offer various concepts to address a constitutive form of communication in organisations. One is "the perpetual states of becoming orientation" that focuses on "communication as a dynamic process that creates, sustain, and transforms organisations" (Putnam et al., 2009; p. 8). In other words, the focus is on the organisational activities that aggregate social interaction among its members. This aggregation of social interaction is what I understand as Mintzberg's (1993) concept of mutual adjustment which leads to coordinated adjustment of activity (McPhee and Zaug, 2001).

The practical implementation of this coordinated adjustment of activity (McPhee and Zaug, 2001) has to be done through some kind of co-orientation in which organisational members relate to each other through a common object of concern (Taylor and Robichaud, 2004). This ‘ common object of concern’ has to be indicated by the management team, as it is not only their legal but also their moral role to keep the organisation, their assets, the employees, and the environment safe (as described by the directors of this company in their annual report, see: Gassco, 2013; p. 8). As the aim is to translate words into activity, the conversation through co-orientation can establish a basis for action while maintaining “the coordination of members of the organisation in responding to a mixed material and social environment” (Taylor and Robichaud, 2004; p. 397). In the context of this doctoral research, it means that through the existing conversations concerning risks and safety behaviour in the organisation, all members are already mutually adjusting interpretations and actions concerning these topics.

The conceptual framework I will present over the next sections explicitly combines key elements from both theoretical perspectives on HRO and CCO, as well as findings from two empirical research projects. By doing so, it provides an answer to the ‘how’ of creating a safety culture in organisations managing high-risk processes. Although it supports the idea of ‘mindful organising’ (Weick and Sutcliffe, 2007) it adds new insights to the practical implementation of a safety culture, whereas Weick and Sutcliffe offer a more holistic approach for creating a safety culture.

3.5 Towards a conceptual framework

Over the next sections I will introduce the various elements of my conceptual framework. The framework itself is visualised in Figure 3-2, at the end of this section. The framework consists of seven elements, whereas the first three (procedures and guidelines, training and exercises, and common language) are the results of initiatives taken by a management team, the last three elements (common mindset, correcting each other, and reporting) are the results of

initiatives taken by employees. Both sets of elements are linked to each other by collective conversations about safety.

3.5.1 Procedures and guidelines

By law, every organisation is obliged to conform to safety and health regulations, be it on a national level (for instance the 1974 Health and Safety at Work Act in the UK, or the Occupational Safety and Health Act of 1970 in the USA) or on an international level (for instance Article 153 of the Safety and Health Legislation of the European Union). European-based organisations working with hazardous products have to adhere to the so-called Seveso I, II or III directives[2]. These directives impose very strict standards for effective enforcement of safety rules. To confirm these standards, such organisations create very demanding operational procedures and guidelines, often referred to as SOPs and SOGs (Standard Operating Procedures and Standard Operating Guidelines), as a means to control risk (Moss, 2001). The gas-receiving terminal that was the topic of my two empirical research projects has 247 SOPs and 300 SOGs in use. The majority of these guidelines and procedures are about the safe use of tools on the plant (see P2) and are formally introduced by the management team in general, and controlled and refined by the Health Safety Environment and Quality (HSEQ) manager. For him, procedures and guidelines are more than just rules of thumb; they are essential for executing operations in a safe way. This was illustrated in one of the interviews at P3: *"It might not be the case we forget a procedure because yesterday everything went fine, so today we do the same thing eyes closed. No, never! Even if we work with the same team tomorrow, we might be in another mood. Therefore: procedures, procedures, and procedures. Period!" (*HSEQ manager).

These SOPs and SOGs are not only perceived by management as pivotal for safe operations, the data of P2 indicated how every individual in this organisation was aware of the procedures and guidelines and its importance for keeping the plant safe. They described guidelines and procedures as *"critical for*

[2] For more information, see: http://ec.europa.eu/environment/seveso/

staying alert to what might go wrong" (OS3), or as a means for anticipating liability. One member of the maintenance team indicated, *"they always have to be up-to-date and correct. If something were to happen one day, they will check all the plans and procedures, and each and every one of us will be liable for any shortcoming"* (MT3).

It could be argued that the dissemination of procedures and guidelines looks very familiar to the mathematical model of communication, as described in Figure 3-1 (see page 59). However, the conceptual framework tries to capture additional dynamics, which contribute to how the procedures and guidelines are interpreted and are actually enacted in the organisation. Although all the procedures and guidelines are transferred to all employees by means of electronic devices, and therefore they might refer to the informational form of communication, the creation and constant adaptation of these procedures and guidelines is based on a collective form of conversation. This was evident in the daily morning meetings, as well as in the formal safety meetings, where employees discuss minor events and work related issues, and how these experiences might add to the improvement or correction of existing procedures. These conversations are fed with experiences from both real events and exercises and trainings. I will elaborate on that in section 3.5.7 ("Reporting").

3.5.2 Training and exercises

In an attempt to disseminate the content and rationale of these SOPs and SOGs all staff are involved in formal and regular trainings and safety exercises (DNV, 2013). This is in line with what Weick and Sutcliffe (2007) emphasise on learning and training as it keeps employees sensitive to the possible consequences of the high-risk processes in their organisation.

In the systematic review of the literature (P1), adapted safety trainings and learning mechanisms were identified as key interventions for risk communication in organisations managing high-risk processes. Findings of my first empirical research project (P2) indicate how employees with an experience of real crisis situations in their previous job emphasise the value of trainings and

crisis simulation exercises. One of the interviewees asserted: *"Crisis exercises are critical, however, the reality is completely different."* P2 indicated how employees who experienced a life-threatening crisis situation are not only sensitive to the major risks in the organisation, but much more concerned about preventing injuries and safety behavioural issues than their colleagues with no real crisis experience. There might be a twofold explanation for this. Firstly, due to their crisis experience they have some kind of knowledge on how systems might break down, quite often by wrong manipulation and how this has an impact on personal injuries. Four out of six interviewees who witnessed a severe crisis situation attributed these incidents to behavioural issues when dealing with systems that eventually lead to personal injuries. Secondly, my research indicated how these persons who experienced a crisis situation have an extensive knowledge of the company's procedures.

Although exercises and trainings may never completely match reality, their aim is more than a mere creating of awareness or sensitivity among employees to the possible consequences of the high-risk processes (Weick and Sutcliffe, 2007). Crisis simulations, for instance, also create automatisms that are required to anticipate and contain critical issues that might arise in operations (see for instance: Harvey et al., 2001; Lambert and Baaij, 2011; Brugghemans and Marynissen, 2013). In that sense, it creates knowledge by acquaintance rather than knowledge by description (Baron and Misovich, 1999), whereas the latter is achieved through a transfer of information, while knowledge by acquaintance is achieved by experience. Therefore, having a collective experience in a crisis simulation might offer the participants the necessary automatisms that can be helpful when dealing with a real crisis situation.

The theoretical basis for this is rooted in the Recognition-Primed Decision (RPD) model, as it indicates how people use prior experiences to categorise situations as a means to make decisions (Klein, 2008). The core concept of recognition-primed decision making is that in critical situations, employees make decisions based on a process of recognition of key elements in the situation that are linked to previously encountered situations stored in memory

(Tissington and Flin, 2005). Consequently, the RPD model is a blend of intuition and analysis; whereas, employees who are faced with a crisis situation make decisions using pattern matching and mental simulation to determine whether the decision could work in the current situation (Lipshitz et al, 2001; Klein, 2008). Pattern matching is the intuitive part**;** and by using pattern matching, people can quickly match the current situations to patterns they know and hence generate solutions and decisions. The core objective of simulation exercises and trainings is to generate a maximum amount of patterns.

3.5.3 Common language

Besides keeping employees sensitive to the possible consequences of the risks in their organisation, this knowledge by acquaintance through trainings and exercises also offers staff a kind of 'common language'. This language differs from the traditional information that employees receive through a mathematical form of communication, as it is based on shared experiences and not on an imposed communicated concept that has no or minimal links to the employees' vocabulary. By collectively reflecting, interacting, and addressing simulated problems, employees acquire specific skills and shared experiences[3]. Moreover, as interpretations and approaches of critical issues are expressed in work group interactions, participants automatically develop and share symbols and meanings concerning risks (Alvesson, 2002), and how to address them. These symbols, based on lessons learned, will be adopted in new artefacts[4], such as procedures, and "will establish new networks of actors and determine whether their subsequent actions are viewed as competent, or not" (Elliott and Macpherson, 2010; p. 579).

Langley and Tsoukas call this linkage between an experience and how people give meaning to that event a "narrative form of knowing" (Langley and Tsoukas,

[3] As an external consultant involved in the interventions of an exploded Fluxys high-pressure gas pipeline in Belgium (July 2004), I witnessed how members of the crisis management team (who had all been through multiple crisis exercises) had a 'déjà-vu' experience during the events following the explosion. In the debriefing sessions, they all witnessed how these prior trainings offered them a kind of 'common mindset' to address this critical situation.

[4] Interestingly, this is what I saw the employees of this gas-receiving terminal do in my consulting work.

2010; p.7). This notion of incorporating linkages and giving meaning is achieved when two or more people's interactions involve existing metaphors-in-use for setting-up organisational wide dialogues (Langley and Tsoukas, 2010).

The data of P3 indicated how a large majority of the interviewees uses this "narrative form of knowing" (Langley and Tsoukas, 2010) as they indicate skills (19 out of 28 employees), experiences (23 out of 28 employees) and oral alignment concerning safety and risks (26 out of 28 employees) - all features people do acquire through trainings and exercises - as pivotal for safe operations. This can be illustrated by the following quote: *"We can only improve our learning through exercises, or real crisis situations. And that's the odd thing, exercises aim to help us avoid crises. The better we learn from these trainings, the more we really understand the procedures, and eventually the more skilled we will be in jointly avoiding or containing dangerous situations"* (OS3).

Furthermore, P3 revealed how everyone at this gas-receiving terminal talks to everyone else about safety, and how these conversations are partly based on trainings concerning safety procedures and guidelines. This might be illustrated by the following example, given by an Operation Supervisor, in which he recalled a minor incident and how they were using a common language (he used the expression *"same wavelength"*) for discussing the problem:

> *"During the night and over the weekends, it's just me and my adjunct who are on the plant. When something happens, we can rely on the on call duty manager. That particular weekend we had an alert in the land valve station or LVS (this is the station outside the premises where the sea pipe comes on land, note researcher). My adjunct went to the LVS and detected a burning smell. We called the on call duty manager and for more than half an hour we had a conversation on how to solve the issue. Immediately we were on the same 'wavelength'. We went through the procedures, examined plausible actions, and tried to make sense of the situation. At the end we jointly agreed to diminish the pressure in the LVS, keep a close eye on the conditions of the LVS, and bring in an external technical team in the morning. Although the procedures didn't*

give us a ready-made answer to the problem, they helped us to achieve agreement through a common vision, call it knowledge base. A couple of days later, we discussed how to adapt a few procedures based on this experience." (OS2)

This example indicates how common knowledge of procedures and shared experiences lead to a "narrative form of knowing" (Langley and Tsoukas, 2010; p.7) which in turn results in coordinated actions and interactions between team members (Weick, 2011) to address a critical situation. In my view this adds a new perspective to what McPhee and Zaug (2009) call 'activity coordination', as they do not stress the importance of a prior common language created through formal structures (such as SOPs and SOGs), and trainings and exercises. In other words, McPhee and Zaug focus on the interactions that align or adjust local work activities (McPhee and Zaug, 2001) as such and in the moment of this activity, and not what might lead to these interactions.

Finally, note the phrase in the aforementioned quote: "*A couple of days later, we discussed how to adapt a few procedures based on this experience"*. This indicates that the dissemination of procedures and guidelines is not based on a mathematical form of communication, but on active conversations about how to improve safety related issues by refining existing procedures and guidelines.

The previous three elements (SOPs and SOGs, training and exercises, and common language) form the more formal 'left' side of my conceptual model (which will be explained in Figure 3-2 on page 79). The following set of elements (collective conversations, common mindset, correcting each other, and reporting) forms a more informal 'right' side of the conceptual model. All of these elements are revealed in my data. This will be explained in the next sections.

3.5.4 Collective conversations about safety

The data of P3 indicates how everyone in the organisation refers to others, and at the same time is indicated by others as an initiator of conversations about

safety (see Figure 2-1 on page 50). This phenomenon is based on the management team's initiative *"to keep this place safe by engaging every single individual in an open safety dialogue" (CEO's quote in P3)*. Or as a new entry in the organisation (AOS3) framed it: *"From day one you're inculcated with this safety dialogue. Immediately! Initially, I was joking to my family that we talk more than work."* These collective conversations have to be seen as the core of this conceptual framework, as these conversations lead to the coordinated adjustment of activity (McPhee and Zaug, 2001) as well.

The ethnographical data of P3 indicates how this organisation has structures that enable these conversations to happen, including two formal and various informal meetings on a daily basis. In the morning meetings various topics concerning safe operations, maintenance works, minor incidents that happened over the last 24 hours, and the like, are discussed among members of the operations staff, maintenance staff, and the HSEQ manager. In the management meeting afterwards, the main issues from the morning meeting are reiterated. Both the ethnographic and the SNA-data of P3 show that every day all members of the management team spend a considerable amount of time on the shop floor talking about safety, and informally interacting with employees about their work, their job satisfaction and sometimes about their personal sorrows (multiple employees indicated for instance the CEOs ability to ask *"compassionate questions"* (Interview OS2), or long standing cordial relationships with members of the management team).

These conversations, both collective and individual, are predominantly rooted in the organisation's vision to avoid *"silent deviations"* (a term the CEO used in his interview in P3), meaning two or more people hiding some kind of information. *"I do not presume that silent deviations do not exist in our organisation, but we make every effort to uncover this by making everything open for discussion"* (CEO). This ingrained attitude to alert or report minor incidents or dangerous situations, even in a very informal way, was illustrated by someone from the administration team: *"It might happen that I just alert a person who's doing something stupid, like standing on a chair instead of a ladder. That's such a tiny*

thing you simply don't report. Or maybe I will, during lunch to the HSEQ manager or someone from operations. Albeit in an informal way" (ADM3). Moreover, almost one third of the employees (12 out of 28 employees) spontaneously mentioned that their organisation does not have a 'blame and shame culture', but rather one that *"creates an environment in which I will check on everyone's safe behaviour, just as everyone is allowed to check mine"* (OS7). This underlines the organisation's aim to avoid silent deviations by creating an environment in which everyone is encouraged to look out for potential flaws.

Therefore, it might be argued that the object of concern in this organisation is safe operations and preoccupation with failure. This forms the common ground for 'co-orientation' (Taylor and Robichaud, 2004) among all organisational members. Through continuous mutual adjustments (Mintzberg, 1993) of meaning concerning risks, formal and informal reporting, the avoidance of unsafe behaviour, and the elimination of potential risks in "*an open safety dialogue"* (quote CEO), they create, sustain, (Conrad and Poole, 1998) and transform this organisation (Putnam et al., 2009) into a high-reliability one (Weick and Sutcliffe, 2007).

In this research I confirmed the existing theory on how communication constitutes organisations, as I could indicate how every individual has conversations with others concerning their work and the organisation itself. However, I extended the existing theory by indicating the role of the management team in the way they create the possibility to have these overall constitutive conversations towards safety related conversations. They achieve this by introducing some form of organisation-wide co-orientation (i.e. open safety dialogue) through formal (i.e. reporting, safety meetings) and informal (i.e. exchanging views and experiences with the HSEQ-manager) alignments and actions. Moreover, the management team offered a clear vision concerning the avoidance of 'silent deviations' in the organisation, and sustained that with a no-blame, no-shame mentality. In summary, although CCO predominantly focuses on how employees have conversations that constitute the organisation,

it does not indicate how a management team can support this process by incorporating these collective conversations into a more standardised activity of discussing safety topics.

3.5.5 Common mindset

Although P2 indicated that all members of this gas-receiving terminal have different interpretations of the present risks in their organisation, the data of P3 demonstrates how they have a continuous conversation about safety that might explain their long-standing safety records (see Part IV, section 4.4.2 on page 253). These open safety dialogues create a kind of mindset or culture that is difficult to capture in words, as "culture is not primarily 'inside' people's heads, but somewhere 'between' the heads of a group of people" (Alvesson, 2002; p. 4). This culture best resembles Weick and Sutcliffe's concept of 'mindful organising' (Weick and Sutcliffe, 2007), which is an overarching prerequisite for high-reliability organisations as it supports a different mindset about those things that can bring an organisation into jeopardy. The encoding of the P3 interviews revealed how all the attitudes and prerequisites for producing a culture of mindful organising (Weick et al., 1999; Weick and Sutcliffe, 2007) are present in this gas-receiving terminal (see Table 3-1 on the next page). However, the interviewees did not equally mention all the elements. 'Thinking differently about authority' and 'thinking differently about strategy' were described more (21 and 18 out of 28 interviewees respectively) than the other three prerequisites for producing a culture for mindful organising (i.e. plans, simplification, and success). Concerning the attitudes that aim to foresee the unforeseeable, the most mentioned elements are communication (26 out of 28 employees), experience (23), deference (21), and skill (19).

	Attitudes that aim to foresee the unforeseeable								Prerequisites for producing a culture of mindful organising					
	Alertness	Boldness	Caution	Communication	Deference	Experience	Paradoxical action	Skill	Authority	Plans	Simplification	Strategy	Success	Totals
MNG 1				4	3	3		2	2	1		1		16
MNG 2	5	1	4	7	6	4	1	2	11	6	3	10	2	62
MNG 3	1			3	1	1	2	2	2		1		1	14
MNG 4	1			2	2	1	1	3	3	1		1		15
OS 1	1			1	1	2		2						7
OS 2		1		2	4	6		3	2					18
OS 3		1	1	2	1	3		3	1					12
OS 4	3		1	3	2		2		3					14
OS 5	1		1	2	1	2		1		1		2		11
OS 6				1		3		1				1		6
OS 7	2		2	1	1	2			2			1		11
OS 8				2										2
AOS 1				3	1	1			1					6
AOS 2	1			1										2
AOS 3	1		2	2	1	2		1						9
AOS 4		2		4	2	1			2	1		3		15
AOS 5	2		3	2					1			3		11
AOS 6	5		3	3	1	2			1					15
AOS 7				1	1	1	3	1	2			4	1	14
MT 1			1	3	1	2		2	1			2		12
MT 2	2		2	5	4	2	1	1	1			3		21
MT 3	1	1	1	3	1	3	1	2	1	2	1	1		18
MT 4	1		1		1	1		1	2			2	2	11
MT 5	1			3		2		4	1			1		12
MT 6				1	2	2		1	1		1	2		10
ADM 1						1		1	2			1		5
ADM 2	4	2	1	2	1	4		1		1		4		20
ADM 3				2					1			1		4
Totals	32	8	23	65	38	51	11	34	43	13	6	43	6	

Table 3-1 Encoding of the P3 interviews, based on attitudes and prerequisites for producing a culture of mindful organising (Weick et al., 1999; Weick and Sutcliffe, 2007)

A detailed description of the analysis of the data, as presented in Table 3-1, is described in Part IV of this doctoral thesis, in the sections 4.7.1 and 4.7.2 on pages 267-269.

According to Antonsen (2009), this common mindset about safety can only flourish in “a ‘good’ safety climate”. He describes a “‘good’ safety climate” as “one where managers at all levels are highly committed to safety; where the workforces express satisfaction with and adherence to the organisation’s safety system; where everyone is risk averse; where there is no pressure towards maximising profits at the expense of safety and where operators as well as managers are highly qualified and competent” (Antonsen, 2009; p. 17). In various interviews, both in P2 and P3, multiple employees quoted the company’s unofficial catchphrase “time and money are no excuses for executing a safe job”, while underlining the management team’s dedication to safety no matter what. That supports Antonsen’s description of a safety climate, and confirms the attitudes and prerequisites for producing a culture of mindful organising (Weick et al., 1999; Weick and Sutcliffe, 2007).

3.5.6 Correcting each other

Through the continuous open safety dialogues, and the common mindset about safety, employees are encouraged to directly approach each other if they pick up on a safety issue that might create a potential dangerous situation. More than 80 percent of interviewees indicate they will immediately address and correct the person who creates an unsafe situation. The following quotes illustrate this attitude:

> *"You don't go tell everyone when you see a safety issue. You immediately address the person himself"* (AOS4).
>
> *"Everyone approaches everyone when it concerns safety related issues. We are all grown-ups. If I do something wrong, I will definitely get a remark. And if the CEO does something wrong, he will be corrected for sure. That's the way we do things around here"* (OS4)
>
> *"I expect everyone in this company to correct me immediately"* (CEO),

This attitude is supported by a no blame, no shame mentality. The main objective is not to punish or blame anyone who makes a mistake (*"you will never be reprimanded"* (OS4)) but *"rather to engage [him or her] in the conversation on how to avoid this in the future"* (MNG2). The management team of this organisation clearly states that every individual is responsible for immediately reporting mishaps or risks, for taking appropriate action, and for learning. Or as a member of the maintenance team reframed it: *"making mistakes is not the end of the world, as long as you report them immediately and learn from your mistake"* (MT3). That is why "*everyone checks each other. Probably unconsciously"* (MT4).

Besides the formal hierarchical lines for giving work orders or for reporting, this organisation has created an informal way of approaching each other concerning safety related issues, independently of the formal reporting structure. It might be argued that acts of giving work orders or reporting can be perceived as a transfer of information, and thus, a mathematical approach of communication between a sender and a receiver. I am arguing however that the informal way of

approaching each other concerning safety issues is more a constitutive form of communication in which one person approaches the other one, regardless of rank or position. In the way they correct each other employees *"discuss the possible consequences of that action"* (MNG4) and by doing so they support and *"confirm [their] mutual role as safety officers"* (AOS1) in this organisation. In other words, the act of approaching and correcting each other is a way of co-orientating towards safety in the organisation, as well as a mental mindset to be preoccupied with failure (Weick and Sutcliffe, 2007).

3.5.7 Reporting

As indicated in the previous paragraphs, the formal and informal reporting of events is crucial in this gas-receiving terminal. The procedures specify that every incident, anomaly or flaw has to be reported in writing. This is not dissimilar from other organisations managing high-risk processes. The distinctive approach in this gas-receiving terminal is in how the reporting forms the basis for collective conversations about safety in the morning meetings, the daily management meetings, and the monthly safety review meetings. In turn, these conversations may lead to new initiatives concerning safety measures, which eventually will be translated in the further development of procedures or guidelines, or into a reformulation of an existing SOP or SOG. According to the CEO of this company, *"if a mistake is based on the wrong interpretation of a procedure, than we need to reinterpret and change the procedure."*

Reporting is perceived by the employees as a way *"to focus on safety"* (OS5), to maintain *"clear agreements on how we do things around here"* (MT3), and to *"improve the procedures continuously"* (MT5). Furthermore, the data from the social network analysis in P3 indicated that social relationships outside of work or good friendships among employees have insignificant impact on reporting safety issues. Employees expect to be treated as *"grown-ups"* (OS4) who "*can all learn something from each other"* (OS2).

This confirms and combines the existing theories, as HRO emphasises on reporting as a means of being sensitive to operations (Weick and Sutcliffe,

2007), while CCO stresses collective conversations concerning safety and how to improve activities (Taylor and Robichaud, 2004) in a safe way.

3.6 Contributions

This process in which each step leads to another, and the process itself becomes a perpetual way of acting, is illustrated in Figure 3-2 on the next page. My data revealed that it is a permanent process of reporting, discussing, alignment, and co-orientation towards safe operations which in itself is the basis for a constitutive approach of risk communication in an organisation managing high-risk processes.

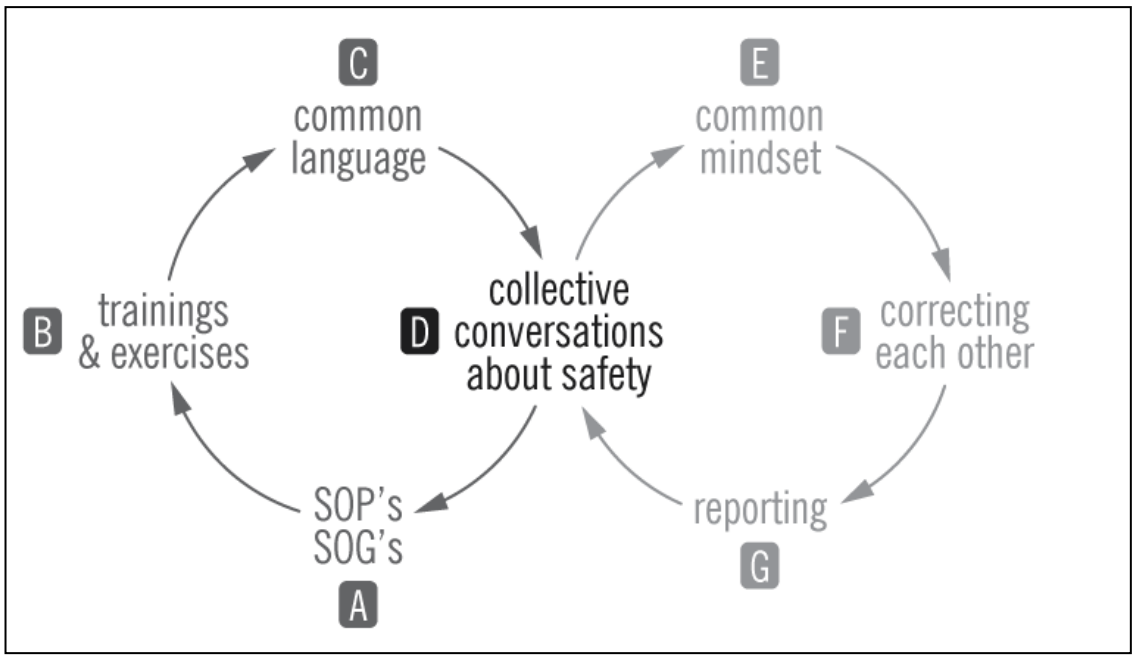

Figure 3-2 Constitutive view of risk communication in an organisation managing high-risk processes

The theoretical and the empirical support for this conceptual framework of a constitutive approach of risk communication are detailed in the table below (Table 3-2).

	Element	Theoretical link	Empirical support
A	SOPs & SOGs	Standard Operating Procedures and Guidelines are essential means to control risks (Moss, 2001)	Guidelines and procedures are perceived as “critical for staying alert to what might go wrong” (P2) and are the basis for a collective form of verbal alignment (P3)
B	Trainings & Exercises	HRO emphasises on learning and training to keep employees sensitive towards the possible consequences of the high-risk processes (Weick & Sutcliffe, 2007). Recognition-Primed Decision indicates how employees use prior experiences to categorise situations (Klein, 2008) and make decisions based on recognition of key elements linked to previously encountered situations (Tissington & Flin, 2005).	Safety trainings and learning mechanisms are key interventions for risk communication (P1). Employees who experienced a real crisis situation emphasise on the critical value of trainings and crisis simulation exercises (P2).
C	Common Language	Langley and Tsoukas refer to a “narrative form of knowing” (Langley & Tsoukas, 2010; p.7) when two or more people’s interactions involve existing metaphors-in-use for setting-up organisational wide dialogues.	A large majority of the interviewees indicates skills, experiences, and oral alignment concerning safety and risks (all features people do acquire through trainings and exercises) as pivotal for safe operations (P3).
D	Collective conversations	The collective conversations among organisational members lead to coordinated adjustment of activity (McPhee & Zaug, 2001) that forms the common ground for ‘co-orientation’ (Taylor & Robichaud, 2004). It is a process of continuous mutual adjustments (Mintzberg, 1993) of meaning concerning risks, formal and informal reporting, the avoidance of unsafe behaviour, and the elimination of potential risks in an open safety dialogue.	P3 indicates how everyone in the organisation refers to others, and at the same time is indicated by others as an initiator of conversations about safety. The ethnographical data of P3 indicates how this organisation has structures that enable these conversations to happen, including two formal and various informal meetings on a daily basis.
E	Common mindset	Weick and Sutcliffe’s (2007) describe a series of attitudes and prerequisites for producing a culture of mindful organising, which is an overarching prerequisite for HROs.	The various data of P2 and P3 demonstrates how employees have a continuous conversation about safety that creates a kind of common mindset. Interview data (P3) revealed how all these attitudes and prerequisites for producing a culture of mindful organising are present in this organisation.
F	Correcting each other	Approaching and correcting each other is a way of co-orientating (Taylor & Robichaud, 2004) towards safety in the organisation, as well as a mental mindset to be preoccupied with failure (Weick & Sutcliffe, 2007).	More than 80 percent of the interviewees (P3) indicate they will immediately address and correct the person who creates an unsafe situation.
G	Reporting	HRO emphasises on reporting as a	Reporting is perceived by the

		means of being sensitive to operations (Weick and Sutcliffe, 2007), while CCO stresses on collective conversations concerning safety and how to improve activities (Taylor and Robichaud, 2004) in a safe way.	employees as a way to focus on safety, to maintain clear agreements on how to do things, and to improve the procedures continuously (P3).

Table 3-2 Theoretical and empirical support for the conceptual framework

This conceptual framework represents two different sets of activities. The left circle includes procedures and guidelines, training and exercises, and a common language based on skills and experiences. The management team instigates all of these elements. The right circle comprises a common mindset, correcting each other, and reporting. These elements might be seen as initiatives that are taken by the employees, although the management team formally supports them. This support is illustrated by the management team's clear vision concerning the avoidance of 'silent deviations' in the organisation, sustained with a 'no-blame, no-shame' mentality. The two circles are linked to each other by the element 'collective conversations about safety'. From the literature on CCO we know that organisations are networks of conversations (Ford, 1999) in which employees constitute the very structuring of the organisation (Boden, 1994), and communication is perceived as central to the social construction of the organisation's reality (Hübner, 2007). My conceptual framework goes one step further in indicating how a management team can benefit from these constitutive conversations by creating the possibilities to have a more standardised activity of discussing safety topics. By doing so, the formal way of discussing safety related issues would become part of day-to-day informal conversations. Therefore, Figure 3-2 elaborates on the formal sender-receiver approach of transferring information (as presented in Figure 3-1 on page 59), which enhances an informal constitutive approach of discussing safety issues (as presented in the right circle).

This constitutive view of risk communication, as presented in the conceptual framework, offers a number of theoretical contributions. Table 3-3 gives an overview of these contributions.

Kind of contribution	Clarification	Indicated in	Detailed description
Confirming and extending existing HRO theory	My research confirms how real-life crisis experiences, trainings, and exercises are key for keeping employees sensitive towards the possible consequences of high-risk processes. The method of Repertory Grid uncovered how employees who experienced a crisis situation came up with more constructs than their colleagues who did not experienced a life-threatening situation at work.	P1 + P2	Part I, p. 44-47 Part II, p. 159-161 Part III, p. 213-217
Extending existing CCO theory	McPhee and Zaug's (2009) concept of 'activity coordination' focuses on alignment of work activities in the moment of this activity, not on what might lead to these alignments. My research indicates the importance of a prior common language created through formal structures (such as SOPs and SOGs), and trainings and exercises, which leads to 'activity coordination'.	P3	Part IV, p. 275-277
Confirming and adjunction of existing HRO and CCO theories	My research indicated a link between the act of approaching and correcting each other, which refers to the CCO-concept of co-orientation (Taylor and Robichaud, 2004) towards safety in the organisation, and the HRO-principle of being preoccupied with failure (Weick and Sutcliffe, 2007).	P3	Part IV, p. 251-253
Confirming and adjunction of existing HRO and CCO theories	My research shows how reporting safety issues is linked to the HRO principle of being sensitive to operations (Weick and Sutcliffe, 2007) as well as to collective conversations concerning safety and how to improve activities in a safe way (Taylor and Robichaud, 2004). By doing so, I confirmed and combined both existing theories.	P3	Part IV, p. 253-255

Table 3-3 Theoretical contributions of the conceptual framework

The key difference with the informational process of communication based on the Mathematical Model of Communication (Shannon and Weaver, 1949), as presented in Figure 3-1, and my conceptual framework for a constitutive view of risk communication, is that the latter is not a linear transfer of information, but a continuous interactive process of creating, discussing, and interpreting meaning based on a common objective of interest, namely safety.

It might be argued that this framework for a constitutive view of risk communication as presented in Figure 3-2 cannot be installed over night. The data captured in the final empirical research project (P3) indicated the pivotal role of the management team, and more specifically the role of the CEO, in the

process of creating a safety culture. This crucial role of the CEO might be illustrated in Table 3-1 (on page 76). This table indicates all the codes for each employee that have been captured in the analysis of the interview data. The two sets of codes refer to the attitudes and prerequisites to produce a culture of mindful organising (Weick et al., 1999; Weick and Sutcliffe, 2007). It is noteworthy that the CEO of this company (indicated as MNG2) is the only person who mentioned all these items of mindful organising.

As this research was not focused on the role of leadership in organisations managing high-risk processes, nor on behaviour, these areas are subjects for further research. In the final chapter of this linking document (see: “5.3 Areas for further research” on pages 91-93) I will elaborate on viable avenues for further exploration of these themes.

In the next chapter, I will translate my findings into practical recommendations for organisations managing high-risk processes.

4 MANAGERIAL IMPLICATIONS

4.1 Introduction

In this section I will indicate two practical implications that are based on my research. The first is based on my conceptual framework for a constitutive view of risk communication in organisations managing high-risk processes. The second implication refers to the academic world and indicates possible ways for including my research findings, and more specifically the constitutive role of communication, into the existing curricula in colleges offering courses in communication science, business science, risk management, and the like.

Before elaborating on the aforementioned implications, I will make a distinction between Behaviour Based Safety (BBS) and my conceptual framework for a constitutive view of risk communication in organisations managing high-risk processes. BBS has become increasingly common in organisations over the last two decades, especially in the oil and gas industry (Antonsen, 2009). However, BBS is somewhat blind to the interpretivist view of enhancing a safety culture as it predominantly emphasises auditing and training. Therefore, I will address a number of fundamental differences between BBS and my conceptual framework in an attempt to make a clear distinction between both approaches.

4.2 Differences between the conceptual framework and BBS

In management practices, Behaviour Based Safety (BBS) is quite often cited as a standard for implementing or improving the safety culture in organisations. The Occupational Safety and Health Administration (OSHA) under the US Department of Labour, for instance, recommends BBS training on their website as an efficient tool for changing human unsafe behaviour.

Rooted in the broader field of organisational behaviour, BBS “focuses on what people do, analyses why they do it, and then applies a research-supported intervention strategy to improve what people do” (Geller, 2001; p. 88). Although

it aims to achieve the same safety culture as my conceptual framework, it differs substantially on various domains.

First and foremost, BBS predominantly focuses on blue-collar workers who execute process activities (Geller, 2001), while my conceptual framework includes all organisational members in a safety dialogue, as safety is not only required for workers, but is every single individual's matter of concern. Secondly, BBS starts from extensive research on organisational members' behaviour, whereas senior or line managers intervene as experts in observing and reporting on workers' safe behaviour. My conceptual framework, on the contrary, starts from tapping into the already existing conversations among employees about safety, and prefers expertise to experts. Thirdly, BBS uses a reward and punishment system in which safe behaviour is rewarded (be it with a bonus system, or with formal recognition) and unsafe behaviour is penalised (be it with a fine, or with public rebuke). The risk of this blame and shame mentality might lead to underreporting accidents and near accidents, and straying towards manipulation instead of improving safety culture (Antonsen, 2009). My proposed framework, on the other hand, tries to motivate employees into being open-minded about safety. And finally, BBS emphasises the directive and formal role of leaders in creating a safety culture through auditing, training, interventions, and guidelines (see for instance: Geller, 2001; Roughton and Mercurio, 2002). Furthermore, BBS-leaders are advised to use persuasive communication strategies (Geller, 2001). This is strikingly opposing to my conceptual framework as it rejects the idea of persuasive communication, but emphasises an open safety dialogue in which the leadership team has a rather supportive and participative role.

Table 4-1 offers an overview of the main differences between BBS (as described by Geller, 2001, p. 88-94) and my conceptual framework for a constitutive view of risk communication.

BBS	Conceptual framework
Focus intervention on observable behaviour	Focus intervention on existing safety conversations
Look for external factors to understand and improve behaviour	Starts from the existing constitutive conversations in the organisation
Direct with activators and motivate with consequences	Clear vision concerning the avoidance of 'silent deviations' in the organisation
Focus on positive consequences to motivate behaviour	Promotes a 'no-blame, no-shame' mentality
Applies the scientific method to improve intervention: DO IT (Define, Observe, Intervene, Test)	Improvement of safety is based on a continuous process of reporting, discussing, alignment, and co-orientation towards safe operations
Use theory to integrate information, not to limit possibilities	Uses formal reporting and informal conversations about improvements of procedures and guidelines
Design interventions with consideration of internal feelings and attitudes	Interventions are based on deference to expertise and the aim to be reluctant to simplifications

Table 4-1 Differences between BBS and the conceptual framework for a constitutive view of risk communication

4.3 Practical use of the framework

My conceptual framework for a constitutive view of risk communication in organisations managing high-risk processes can be transformed into a practical approach for executive management teams. It proposes how standardised safety procedures and guidelines might become part of the daily informal conversations among employees. This can be achieved by combining two distinct sets of activities: one set of elements that is instigated by the management team and another that is based on activities taken by the employees. The link between both lies in the collective conversations employees already have. The conceptual framework indicates how a management team might benefit from these conversations by incorporating them into a more standardised activity of discussing safety topics. By doing so, the formal way of discussing safety related issues would become part of day-to-day informal conversations.

This conceptual framework might be very powerful for management teams of organisations managing high-risk technologies, as they not only recognise all

the elements of the framework, but also work with most of these concepts on a daily basis. This does not mean that working with or recognising concepts equals proper use. Therefore, the notion of how to incorporate and support the collective conversations about safety might be the subject for further training and implementation in the organisation's strategy.

4.4 Directions for adapting curricula

Over the last decades, innumerable professionals have been taught all kinds of mathematical communication models. However, when confronted with organisational questions that require some kind of behavioural change, they feel disoriented and clueless about how to engage staff. This observation comes from my personal experiences in multiple organisations worldwide. Still, they keep on using the traditional sender-receiver communication models. Even though these models did not meet the expectations in the latest communication campaigns, the same obsolete methods are used over and over again. According to van Woerkum, these people "should be recalled [to college], like Toyota does, for a minor but crucial repair: that [communication] model should be removed" (van Woerkum, 2011; p. 10 – translated from original Dutch text).

I would like to join van Woerkum by appealing for broadening existing curricula in academic institutions offering various courses in which communication in general, and the applied use of communication theory in particular has a prominent role. The findings of my research, and more specifically the constitutive role of communication and the conceptual framework that emphasise collective conversations rather than a transfer of information, inhibit valuable insights for future business leaders, such as Masters in Management, Masters in Communication, MBAs, DBAs, PhDs in management, and the like. Offering new insights, such as CCO, to the existing curricula might help future managers and leaders to expand their view on organisations as networks of communicative processes (Blaschke et al., 2012) and how they might participate in these constitutive conversations. This might be done in very

practical classes in which participants learn to capture ongoing conversations, and how they might relate and contribute to this.

5 LIMITATIONS AND AREAS FOR FURTHER RESEARCH

5.1 Introduction

This study presents a conceptual framework for a constitutive view of risk communication in organisations managing high-risk processes. As this framework is built on two evolving fields of research, namely HRO and CCO, there are multiple aspects that require further exploration. Moreover, I am very well aware that this doctoral thesis intrinsically embodies limitations. In the following paragraphs I will highlight these limitations as well as some areas for further research.

5.2 Limitations

A first limitation concerns my framework for a constitutive view of risk communication in organisations managing high-risk processes itself. Although this framework is based on research findings and theoretical insights from multiple scholars in various fields of the social sciences, it is still a theoretical one that needs to be tested and validated in further research.

A second limitation is an empirical one, and linked to the scope of data gathering. This research was done in a small but independent division of an internationally operating company. As all the positions and levels any other company have are represented in my sample, it did not only give the advantage to examine 100 percent of the population, but also to have a depth rather than a breadth analysis of the data. Still, it is recommended to widen the empirical scope of this topic to organisations managing high-risk processes with a greater number of staff and with even more complex high-risk processes.

Linking to the previous limitation, it might be argued that other methods than used in this research can offer new or innovative insights into these interactive processes. However, as Blaschke and his colleagues (2012) indicate, the range of methodologies to analyse the relation between communication and

organisation are rather limited. Still, it might for instance be recommendable to apply action research to study how these organisations create a safety culture in difficult environments (Antonsen et al., 2007) by using co-orientation techniques (Taylor and Robichaud, 2004) to achieve collective safety conversations for instance.

A fourth limitation is that this research examined some kind of 'positive deviant' (Pascale and Sternin, 2005; Pascale et al., 2010) in terms of supporting a safety dialogue among staff. Therefore, the presented framework for creating a safety culture in organisations managing high-risk processes is based on one particular organisation, a sole example in the field of organisations managing high-risk processes. It might be the case that this gas-receiving terminal is rather an exception than the norm in the industry. This limitation links to a recommendation for further research, and will be discussed in the next section.

A fifth and theoretical limitation concerns the rather new and evolving fields of Process Organisation Studies (Hernes, 2007) and Communication Constitutes Organisations (Putnam and Nicotera, 2010). Only recently (in July 2013) the Board of the European Group of Organizational Studies (EGOS) approved a so-called "Standing Working Group" in the field of Organisation as Communication. Over the next five years, this group will address new theoretical and practical insights in the constitutive relation between organisation and communication (OAS, 2013). This means considerable research is needed to uncover all the implications of CCO. One might argue, for instance, that in large organisations with multiple divisions or physically divided branches the conversations – and thus the safety conversations as well – vary. This might have an impact on the approach to create an open dialogue concerning collective conversations about safety in these types of organisations.

5.3 Areas for further research

Although most of the aforementioned limitations comprise directions for further research, as every limitation opens new directions for further exploration and development, this section points to other areas that require more scrutiny

regarding the conceptual framework for a constitutive view of risk communication in organisations managing high-risk processes.

Findings from my first empirical research project (Project 2) indicated how people with experience of a real life-threatening crisis situation seem to be more sensitive to risks and safe behaviour. This finding was also confirmed in research I was involved in, separate from this doctoral thesis, examining a real crisis situation as experienced by a team of fire-fighters, and its impact on the post risk aversive behaviour of these men (Brugghemans and Marynissen, 2013). Still, there is a much-needed area to explore on the design and impact of crisis simulations and safety drills in organisations managing high-risk processes.

The role of management is frequently mentioned in the literature on organisations managing high-risk processes (see for instance: Groeneweg, 2002; Specht et al., 2006; Antonsen, 2009; Lekka and Sugden, 2011; Clarke, 2013) and in risk communication literature in general (see for instance: Gurabardhi et al., 2005, Conchie and Burns, 2008; Hambach et al., 2011). Although my research indicates the pivotal role of the CEO of this gas-receiving terminal in the creation of a safety culture, there is an urgent need for more insights into the 'what' and 'how' of management in these types of organisations.

Linked to this, there is still a long way to go to acquire more evidence-based insights in how the process of communication that constitutes (Putnam et al., 2009) mindful organisations (Weick and Sutcliffe, 2007) generates safe or risk aversive behaviour in organisations that manage high-risk processes. To date, there is little empirical research in this field that might help to disseminate best practices or recommendations. Although there has been research in the field of discourse analysis (see for instance: Fairhurst and Putnam, 2004; Zoller and Fairhurst, 2007; Fairhurst, 2009; Fairhurst and Uhl-Bien, 2012) that offers directions for practice, still, it has never been applied to the field of high-reliability organisations or companies managing high-risk processes in a complex environment. Therefore, the link between how employees make sense

of the present risks in their organisation and how that leads to safe behaviour could be the focus for further research.

As mentioned before in the limitations section, my empirical research was based on a single independent division of an internationally operating company in gas and oil industry. It is highly recommended to examine other organisations dealing with high-risk processes, while comparing the results with the theoretical and practical findings of my research. Furthermore, it might be questionable whether this conceptual framework for creating a safety culture is applicable as well in other industries such as nuclear power plants, air control centres, or military activities; as they are heavily structured around procedures and guidelines (Perrow, 1999; Rochlin, 1999). However, based on the insights derived from my research and the analysis of the existing HRO and CCO literature, I would argue that especially these types of industries might benefit from using my conceptual framework. My proposed framework indicates how a whole set of elements supports the collective conversations about safety that leads to the co-creation of safety guidelines and procedures.

5.4 Conclusions

A critical reader might wonder whether this gas-receiving terminal that was the subject of my research is ‘too good to be true’. Although it might be described as a ‘positive deviant’ in the way it has a constitutive view of risk communication, it does not differ from any other organisation when it comes to envy, egos, power, and politics. Still, the organisational members of this gas-receiving terminal seem to handle these elements as subsidiary to having an open safety dialogue.

This doctoral thesis offers a conceptual framework to support a constitutive form of risk communication in organisations managing high-risk processes with the aim to create a safety culture in this type of organisations. Although this framework offers substantial new insights to the existing literature domains of risk communication, CCO, HRO, and organisations managing high-risk

processes in general, it contains several limitations and challenges for further research.

Together with present and future alumni of the Cranfield executive DBA programme, and with a dozen practitioners and academics in the field of organisations managing high-risk processes, I recently founded a European network. As discussed at the inauguration meeting in August 2013, we aim to explore and develop various topics in this field over the next years. One of them will be the applied research into the design and evaluation of crisis simulations in HROs. Therefore, I am delighted that this doctoral thesis is not the end of an intellectual enriching process, but rather the start of new challenging one.

PART II: SYSTEMATIC LITERATURE REVIEW

ABSTRACT

Past research on the relationship of risk communication on risk perception is predominantly focused on the way civilians deal with risk perceptions and messages about possible danger. Little research on this particular domain is done in organisational contexts, or more specifically in complex interactive and tightly coupled organisations. Evaluations of recent industrial incidents indicate that despite all existing communication tools and safety trainings the importance of risk communication and its impact on the employees' risk perception is underestimated. This might indicate a deficiency in the solution-oriented knowledge about the relationship between risk communication and risk perception.

This research systematically reviews the existing literature on the relationship between risk communication and risk perception in the domain of organisations with complex interactive and tightly coupled systems since 1990. In order to research the literature rigorously, the so-called 'CIMO-logic' (Denyer et al., 2008) is applied. CIMO-logic involves a combination of a problematic Context, for which a certain Intervention type produces, through specified generative Mechanisms, the intended Outcome. The rationale is that by examining Context, Interventions, Mechanisms and Outcomes in the specific domain of risk communication and risk perception in complex interactive and tightly coupled organisations, recommendations can be made to improve risk communication practices in these organisations. The main finding indicates various leadership capabilities as dominant interventions that generate two distinct information-processing mechanisms. These interventions are, among others, adding different expertise to a decision process, the introduction of adapted safety trainings, and comprehensible hierarchical communication that refers to the employees' problem domain familiarity. Based on the reviewed literature, directions for future research are indicated.

1 INTRODUCTION

1.1 Need for deeper insights

In research as well as in industrial practice, great efforts are made to improve safety, not only at systems' level, but also on individual-centred measures to increase the safety at high-risk production systems (Grote and Künzler, 2000). Recent incidents, such as the explosion of a Fluxys gas-pipeline in Ghislengien (Belgium, July 2004), the explosion at the BP Texas City Refinery which caused 15 deaths and over 170 injuries (USA, March 2005), the crash of Turkish Airlines flight TK1951 near Schiphol Airport (The Netherlands, February 2009), or the explosion on BP's Deepwater Horizon (Gulf of Mexico, April 2010) - just to mention a few - are all rooted in some kind of failure. Investigations following these disasters indicated that despite all the technological safety processes, quite often the root causes of these incidents lie in human error. Although employees were well trained in safety procedures, they often did not take into account the importance of these processes (Rochlin, 1999) and did not act accordingly. For instance a Safety Review Panel that was investigating the explosion at the BP plant in Texas mentioned systemic errors in their 350 page report such as deficiencies in leadership, internal communication, core values, and inconsistency in the messages about process safety as the root causes of this tragedy (US Safety Review Panel, 2007).

Hence, there is a disconnection between conveying safety information and people acting on that information. In a search for the root causes of the disaster at the Bhopal methyl isocyanate (MIC) plant of Union Carbide in 1984, Weick (2010) concludes that one of the reasons that led to that disaster was the lack of sensemaking regarding the safety procedures on the part of those who were supposed to control this plant. All the operators at the MIC plant in Bhopal received the standard safety procedures, but no one checked if the operators properly understood them and if they made sense to them. This sheds light on the divide between knowing and acting, or the divide between one person giving information and others knowing what it means, and then being able to act upon

it. It also illustrates the importance for deeper insights into the relationship between risk communication and risk perception in complex interactive and tightly coupled organisations. In the next paragraphs I will elaborate on the different concepts I have introduced so far, such as complex interactive and tightly coupled systems, risk, perception, and risk communication.

As a consultant in the field of risk and crisis communication, I am often confronted with managers who communicate to their subordinates about the need for safety, the existing risks and how to deal with them, but often with little to no success. It is my observation that organisations struggle to find the right 'tone of voice' to connect with the people's perception concerning the risk issue at hand. Reason (1997) suggests that open communication impacts safe behaviour, and reduces the number of accidents in the workplace. However, there is little empirical evidence to support this proposition. Although many scholars (e.g., Slovic, 2000; Morgan et al., 2002; Breakwell, 2007; Slovic, 2010) suggest answers to the question of how communication can have an impact on perception, and subsequently behaviour, most of the propositions formulated are based on findings in empirical research among civilians in general. When it comes to communicating risk in organisations with the intention to influence safety perceptions and subsequent attitudes in the workforce, very little empirical research has been conducted (Conchie et al., 2006). An important question central to this issue relates to how perceptions are confirmed, constructed, or influenced by communication.

In her book *The Psychology of Risk*, Glynis Breakwell devotes a full chapter on risk communication. Breakwell states that "one thing that makes [risk communication] interesting, if not unique, is that it seems very difficult to do well" (Breakwell, 2007, p. 130). Morgan and his colleagues go even further by stating that "one cannot find a clear analysis of what needs to be communicated, nor solid evidence that messages have achieved their impact. Nor can one find tested procedures for ensuring the credibility of communication" (Morgan et al., 2002, p. 3). Both quotes illustrate the urgent need for a profound understanding of risk communication in organisations.

In the next sections I will introduce what is known about risk, risk perception, risk communication, and theories defining organisations that deal with risks. The majority of these findings stem from a scoping study I carried out on this topic. According to Tranfield and his colleagues (2003), a scoping study is necessary in management research to assess the relevance and size of the literature and to delimit the subject area or topic. In October 2010, this scoping study, entitled *An exploration into how risk communication influences risk perception, and the role of trust in that process*, was presented to the supervisory panel and accepted for further elaboration in the form of a systematic review.

First, I will demarcate the field of this research, and explain the concept of complex interactive and tightly coupled systems.

1.2 Complex interactive and tightly coupled organisations

In this systematic review I focus on organisations that have to perform in specific settings where they constantly face a potential for error that might have a disastrous consequence on third-party victims (innocent bystanders) and fourth-party victims (fetuses and future generations) (Perrow, 1999). These organisations have no choice but to function reliably, in order to avert serious harm (Weick and Sitcliffe, 2007). It could be argued that all of these organisations have five characteristics in common:

1. They use high levels of energy to transform input into output (Shrivastava et al., 2009),
2. These organisations have to perform at high tempo for a long time without damaging themselves or others (Klein et al., 1995),
3. In the event of a fatal failure, the consequences will not only have a massive impact on the organisation and its members, it will have a severe impact on third-party victims, the environment, and even the sector in which they operate as well (Shrivastava et al., 2009),
4. The processes these organisations control are tightly coupled and deal with complex interactive systems (Perrow, 1999),

5. When danger occurs to these organisations, they often cannot stop the production process immediately, fix the problem, and continue their operations (Klein et al., 1995).

Table 1-1 maps out a number of different types of organisations that all face certain risks. It becomes apparent that only a limited number of these organisations meet all the five previously defined criteria. These organisations are nuclear power plants, chemical hazardous plants, aircrafts, and offshore and onshore gas plants. All of the other examples lack one or more characteristics.

	High levels of energy in production process	High level of performance	High impact in case of failure	Tightly coupled processes and interactive systems	Process cannot be stopped in case of danger
Nuclear power plant	X	X	X	X	X
Chemical hazardous plant	X	X	X	X	X
Offshore / onshore gas plant	X	X	X	X	X
Aircraft	X	X	X	X	X
Air control system		X	X		X
Mining			X		
Hospital		X	X		X
Fire brigade			X		
Power grids	X	X	X		
R&D firm			X		X
Bank			X		X

Table 1-1 Organisations facing risks based on five characteristics

According to Perrow, the organisations that meet all five criteria are organisations that manage complex interactive and tightly coupled systems (Perrow, 1999; p. 327). Coupling concerns the degree to which certain actions in one part of the system directly affect other parts in the system. In other words, the term ‘tight coupling’ means, “there is no slack or buffer or give between two items. What happens in one directly affects what happens in the

other" (Perrow, 1999; p. 90). Interactive complexity refers to how the different parts or components in a system interact. These "connections are not only adjacent, serial ones, but can multiply as other parts or units or subsystems are reached" (Perrow, 1999; p. 75). As a consequence, these complex interactive systems cannot be easily shut down or bypassed and fixed as soon as something is happening. The opposite of a complex interactive system is a linear interactive system. In a linear interactive system "production is carried out through a series or sequence of steps laid out in a line" (Perrow, 1999; p. 72), while the number of parts is irrelevant.

Figure 1-1 illustrates the four quadrants, formed by a two-by-two dimension of complex/linear interactions and tight/loose coupling systems (Perrow, 1999; p. 327). The type of organisations as presented in quadrant 2 (complex interactions/tight coupling) are the kind of organisations this systematic review focuses on.

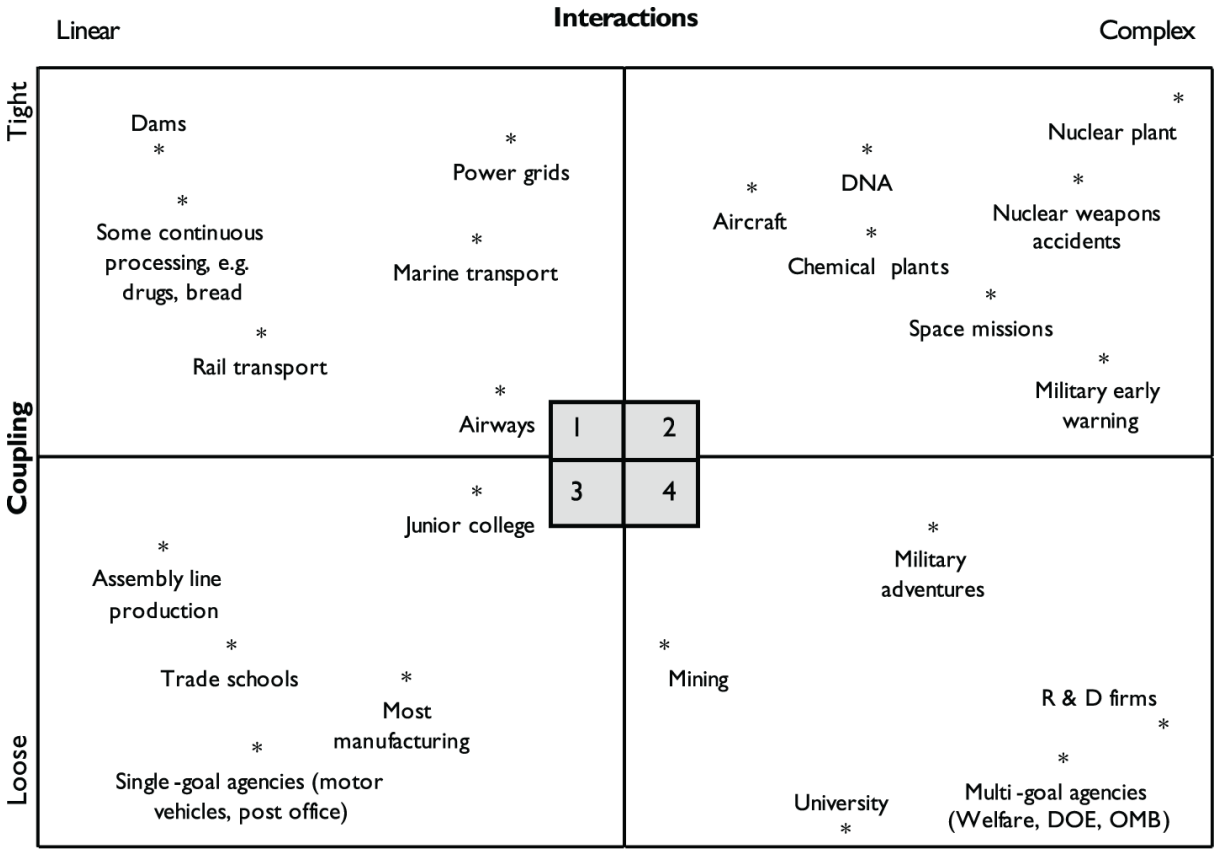

Figure 1-1 Interaction/Coupling chart (taken from Perrow, 1999; p. 327)

In the next paragraph (1.3.1 Theories) I will elaborate on different theories in the domain of organisational risk. It will become apparent that this notion of 'complex interactive and tightly coupled systems' is accepted by and used in the different theories on organisational risks.

1.3 Literature domains

In this section I will introduce the main findings from the scoping study concerning the key domains in the literature under review: theories, risk, risk perception, communication, and risk communication. I will also highlight the distinct theoretical views in the literature on organisations managing high-risks.

1.3.1 Theories

The literature on organisations dealing with complex interactive and tightly coupled systems can be broken down into beliefs concerning the root causes of an incident, and a theoretical approach in the nature of accidents and how to avoid, trap or mitigate failures through organisational design and management (Denyer et al., 2008).

Three schools of thought focus on the root causes of a failure or error: one that adheres to human error, a second one to mechanical or technical failure, and a third one to systems failure. An accident might thus be attributed to a mistake made by one or more operators (human error), a technical failure in an operation (such as a faulty valve that leads to a sudden eruption of toxic substances), or a wider systems failure such as deficiencies in leadership, lack of trust or inconsistent communication. To avoid or mitigate these failures, there are two opposing theoretical approaches (NAT and HRO), and one (OST) that attempts to resolve the longstanding debate between the former ones.

Normal Accident Theory (NAT) argues that tightly coupled and interactively complex organisations cannot prevent accidents. It is in their very nature that complex and tightly coupled structures inevitably trigger system-wide accidents (Perrow, 1999). And once that chain reaction is set in motion, due to its complexity and tight-coupled structure, human beings are unable to intervene.

Therefore, NAT heavily focuses on the structure of the systems. However, it predicts that every once in a while every system will break and cause accidents. This theory was explained in Charles Perrow's seminal work *Normal Accidents* (Perrow, 1984; Perrow, 1999).

The theoretical field of High-Reliability Organisations (HRO) also emerged in the 1980s when scholars from the so-called 'Berkeley group' at the University of California studied how organisations operating with high-hazard technologies manage to remain accident-free for impressive lengths of time while meeting high production goals (Denyer et al., 2008; Shrivastava et al., 2009). Although HRO has a different view on managing risks than NAT does, it accepts the notion of complex interactive and tightly coupled systems (Weick and Sutcliffe, 2007; p. 90-92). However, HRO focuses on how organisations can "create mindful infrastructures that diminish or even postpone damage produced by unexpected events and impair reliable performance" (Weick and Sutcliffe, 2007; p. 2). HRO argues that organisations can avoid failures by the early tracking of small failures, reluctance to oversimplification, remaining sensitive to operations, maintaining capabilities for resilience, and by deference to expertise. High-reliability theorists emphasise the human errors school of thought (Reason, 1997), which suggest that failures can be attributed to people.

Table 1-2 illustrates the -quite often- opposing views, based on Shrivastava et al. (2009). Although this table only offers the main differences between NAT and HRO, it indicates a different view on organisational accidents, and how to anticipate or postpone them.

Normal Accident Theory (NAT)	High-Reliability Organisations (HRO)
Accidents cannot be prevented	Accidents may be postponed
Focus on structure	Focus on processes
Human beings are unable to intervene once the chain reaction is set in motion owing to interactive complexity and tight coupling	Human beings and organisations are assumed to cause disaster and are accorded the power to intervene
Complex and tightly coupled structures inevitably trigger system-wide accidents	Organisational initiatives can prevent accidents
Importing a notion of reliability from the	Organisations must be 'mindful'

engineering discipline	
Systems can be divided into four levels: 1) an individual part (e.g., a valve), 2) functionally related collections of individual parts, 3) arrays of units make a subsystem, 4) combined subsystems make a system. Failures at the first two levels are called 'incidents', disruptions at levels 3 and 4 are 'accidents'	Reliability is the ability to maintain and execute error-free operations through 1) the early tracking of small failures, 2) reluctance to oversimplification, 3) remaining sensitive to operations, 4) maintaining capabilities for resilience, and by 5) deference to expertise
Focus on systems levels 3 and 4	Introduction of several constructs that may have relevance for non-HROs
NAT predicts that every once in a while systems will break down and cause accidents, no matter how much effort and wisdom is invested to avoid system accidents	HRO predicts safety for organisations that are totally committed to high-reliability practices
Point to the moment when accidents eventually take place	Focus on accident-free environments that have existed for a long period

Table 1-2 Normal Accident Theory versus High-Reliability Organisations

The third theoretical perspective on organisational accidents and how to mitigate or postpone them is offered in the Open Systems Theory (OST). In an attempt to resolve the longstanding debate between NAT and HRO, Shrivastava et al. (2009) introduce the concept of open systems. Based on the four quadrants of the NAT, formed by a two-by-two dimension of complex/linear interactions and tight/loose coupling systems, Shrivastava and his colleagues reframed these dimensions into high/low energy levels and a high/low knowledge gap. In the high knowledge gap/high energy level quadrant, we find nuclear power plants, aircrafts, chemical plants, space missions, etc. This is very similar to Perrow's (1999) concept of tight coupled/complex interactions. Although both NAT and OST focus on organisations that are tightly coupled and interactively complex, OST excludes military early warning systems and nuclear weapon systems as they do not involve transformation processes. DNA recombinant technologies are omitted as well "as they do not involve high levels of energy" (Shrivastava et al., 2009; p. 1381).

Figure 1-2 illustrates the adapted two-by-two dimension of complex/linear interactions and tight/loose coupling systems (Perrow, 1999) into a two-by-to dimension of low/high energy levels and low/high knowledge gap (Shrivastava et al., 2009).

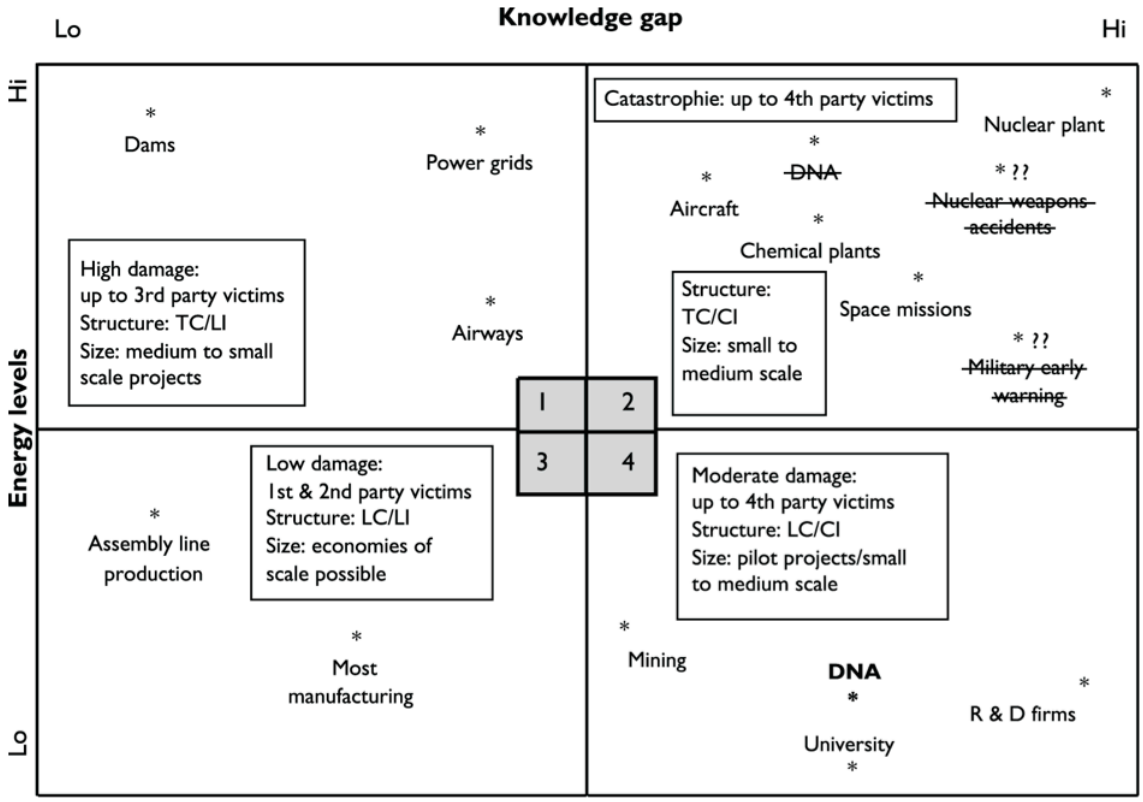

Figure 1-2 Knowledge/Energy chart (taken from Shrivastava et al., 2009; p. 1381)

Furthermore, Shrivastava and his colleagues interpret open systems as containing the following properties (Shrivastava et al., 2009; p. 1376-1380):

- Permeable boundaries: an open system is distinguished from its environment by an arbitrary boundary. However, these boundaries are permeable, indistinct and dynamic.
- Energy transformation: through these permeable boundaries, open systems receive inputs from the environment, transform these inputs into outputs, and exchange their outputs for new inputs. This input-transformation-output cycle is a dynamic process that involves conversion of energy from one form to another.
- Negentropy: one of the fundamental laws of nature is that energy can neither be created nor destroyed; it can only be made to change its form. Some unusable energy does not escape to the external environment; it accumulates within the system itself. This accumulation of unusable energy within the system is a form of entropy. Entropy can thus be

defined as a measure of disorder or randomness in energy. Entropy in any closed part of the universe tends to increase with the passage of time. However, open systems appear to defy this because the amount of order in them always exceeds the amount of disorder. Thus open systems are said to have negative entropy, i.e. they are negentropic.

- Homeostasis: open systems rely on feedback loops to maintain equilibrium with an ever-changing external environment. Both positive and negative feedback ensure survival of a system even as the system continues to grow. This property that maintains equilibrium and allows for stable expansion is called homeostasis.
- Requisite variety: this is the variety of numbers in which a system can exist. Variety is a measure of complexity. A complicated system has a large variety, meaning it can occupy a large number of states. It can be claimed that a system needs variety to combat variety. The law of requisite variety tells us that a system can insulate itself from the complexity of the external environment by making itself complex

The brief examination of the distinctive theories in the field of complex interactive and tightly coupled organisations has identified several ontological differences. However, NAT, HRO, and OST all accept the notion of complex interactive and tightly coupled systems.

From an interpretivist point of view, I rather adhere the theory of high-reliability organisations and the human error school of thought that focuses on the root causes of a failure. However, it is important to place my research interests within the wider debate in order to synthesise different findings of the relationship between risk communication and risk perception, and its effects on organisational safety behaviour. As indicated by Denyer and Tranfield (2006) this kind of analysing distinct epistemological and ontological differences can provide important and effective means of creating practical management knowledge.

1.3.2 Risk

Generally, risk is defined in terms of two dimensions; the first concerns probabilities, the second concerns effects (Breakwell, 2007). Risk refers to the probability or chance individual people, governments and industries take, but this can be linked to positive and negative perceptions. Effect, the second dimension of risk, is linked to a dominant view in the literature that refers to risk as a calculation of chance every individual, government or industries takes, and that is associated to both positive and negative outcomes. In this view, risk can be measured, calculated, and controlled. Scholars such as Perrow (1999), Groeneweg (2002), and Leiss (2004) are a few of the authors that defend this view on risk.

A more interpretivist view on risk is presented by Slovic (2000), who argues that human beings have invented the concept of risk to cope with the dangers and uncertainties of life. Therefore, risk is not something tangible, but rather a concept that is constructed in the mind, perception and emotion of every individual (Slovic, 2000). Consequently the interpretation of risk can vary remarkably among individuals, or, as Gurabardhi and Gutteling argue, “the concept ‘risk’ means different things to different people” (Gurabardhi and Gutteling, 2002, p. 428), in different situations (Ganzach et al., 2008).

Regardless of how people perceive risk and the way to deal with it, be it as a tangible calculation of chance to win or lose, be it as a concept or a mental construction, most people cannot and do not like to deal with the negative consequences of risk (Slovic, 2010). One of the reasons why is the complexity of risks (Meijnders et al., 2009). Very often the statistical analyses by those involved in risk assessment do not make sense to lay persons. Although civilians become more educated about risks, they become harder to understand (Leiss, 2004; Slovic, 2010). A second motivation for aversive reactions to risk can be wealth; the more we have to lose, the more we are afraid of the negative impact of risks (Leiss, 2004). A third aspect that leads to an aversive attitude towards risk is a mental shift with regards to the origin of disasters (Coan,

2002). When less than five decades ago a natural catastrophe or major incident happened, it was perceived as an act of god. Nowadays this faith in a higher power has decreased and the media and victims are eager to go after the offender, and subsequently compensation (Marynissen et al., 2010). This might be illustrated by the following example. At the time I was writing this systematic review project, Belgium was confronted with a disaster at a large open-air music festival, called Pukkelpop. In the late afternoon of 18 August 2011, a local tornado tore down a large marquee and several trees, with more than 50,000 music fans desperately looking for a place to shelter. Five festival-goers, predominantly youngsters, were killed instantly, and more than 140 others were injured. Some of them were badly injured, and were fighting for their lives. Within a couple of hours after this tragedy which was caused by a force of nature, the public opinion started questioning the responsibility of the festival's organising committee, and even the role of the mayor and the rescue teams in their response to prevent or to intervene at the place of disaster.

Based on these insights, the definition that I am using is that risk is socially constructed, and thus both an individual and a collective interpretation of a concept that is based on the chance to lose or gain something, which can individually or collectively trigger associated perceptions that might have an impact on individual, group, institutional or societal level.

In the next section I will elaborate on how risk is perceived and what the mental models about risk provoke on individual and collective level.

1.3.3 Perception

The term "perception" appears in various domains such as sociology, psychology, philosophy, and even in the field of biology (Mezias and Starbuck, 2003), and its origin is rooted in the attribution theory and the cognitive theory (Scott and Marshall, 2005). Attribution theory deals with the rules that most people use when they try to infer the causes of behaviour they observe, and generally attribute their own behaviour to the situation in which they find themselves. The cognitive theory is a major cluster of theories in social

psychology that focus on the links between mental processes such as perception, attitudes, decision-making, and social behaviour. Looking for an appropriate terminology for 'perception', different alternatives are mentioned in the literature, such as sensemaking (Weick, 1993), cognitive frameworks (Labianca et al., 2000; Kahneman, 2011), schemas (Labianca et al. 2000), frames (Kahneman and Tversky, 1979), or mental models (Johnson-Laird, 1983).

Definitions of the term "perception" vary as well. In an effort to avoid linguistic differences, Mezias and Starbuck assume that "the term perception has its fundamental meaning: apprehension by means of the senses or of the mind" (Mezias and Starbuck, 2003, p. 4). According to Labianca and his colleagues perceptions are "generalized cognitive frameworks that give form and meaning to experience, and contain general knowledge to a domain" (Labianca et al., 2000, p. 237). Barr and Huff also look at perception as cognitive representations individuals use, but they perceive it as a more dynamic process, as "a method to make sense of and act within their environments in order to make the right decisions" (Barr and Huff, 1997, p. 329). Buchanan and Huczynski support this view and state "perception is the dynamic psychological process responsible for attending to, organizing and interpreting sensory data" (Buchanan and Huczynski, 2010, p. 236).

Therefore, the definition that I am using is based on Barr and Huff's (1997) view that perceptions are dynamic processes that lead to decisions and subsequent behaviour, and are largely based on individual and collective schemas, frames, or mental models and the way people try to fit new information into these existing schemas, frames, or mental models.

Linking these insights to risk perception, Slovic states that perceptions of risk are inversely correlated to perceived benefit (Slovic, 2010, p. xxi). In other words, if the benefit of a certain risk is perceived as high, the perception of this risk will be assessed as rather low. These insights were the basis for further research in the role feelings serve as important cues for judging risk and benefit, and lead to the theory of affect heuristic (Slovic et al., 2002). According

to Slovic, “affect refers to specific feelings of ‘goodness’ or ‘badness’ experienced with or without conscious awareness” (Slovic, 2010, p. 70). In other words, human beings form their decisions primarily based on feelings and not on reasoning, as feelings occur rapidly and automatically. This is what I refer to in the following paragraph about ‘affect heuristic’.

The scoping study identified a gap in the literature when it comes to applying the theory of affect heuristic in organisational settings. All of the research on affect heuristic I examined is focused on public perceptions of risks and benefits. As we can accept that all organisational members are members of a community as well, the question can be raised if the conclusions made by the theory of affect heuristic are also applicable in organisational settings? Or there might be other rules, restrictions, or mechanisms in place that impact a risky decision-making process in a way it is no longer solely based on feelings. Therefore, the question can be raised whether organisational communication in general, and risk communication in particular, can moderate or impact these feelings for the benefit of both the individual and the organisation?

1.3.4 Communication

In this systematic review, communication is considered as the process of establishing meaning (Scott and Marshall, 2005) by use of the verbal and non-verbal exchange of information, formal as well as informal (Barnes et al., 2007). The literature on organisational communication is more dominated by a desire for social order (Shockley-Zalabak, 2009) and good organisational citizenship behaviour (Al Eslami Kandlousi et al., 2010). This behaviour is based largely on individual and collective schemas, frames, or mental models. The aim of most organisational communication practices is to transfer information in order to fit the new data into the existing schemas, frames, or mental models of those who receive the information (Marynissen, 2011). In the literature these schemas, frames, or mental models are perceived as the basis for perceptions. The key question, though, is how perceptions are confirmed, constructed, or influenced by communication.

The problem with the literature on organisational communication is less linear than presented. Individuals never receive one single, clear pronounced message concerning an organisational issue. Donnelon and her colleagues introduce the concept of “equifinal meanings” for different interpretations of a message, but similar behavioural implications (Donnelon et al., 1986, p. 44). Although organisational members collectively act in the same way, each of them has a different understanding of the conveyed information. However, the concept of equifinal meanings is based on the interpretation of one single message and the respondents’ reported intention for action. This example illustrates how a large part of studies, theories or methodologies are based on clinical-type experiments using a single message from one source. Consequently, they are inadequate to understand in full the relationship between communication and perception.

The second theme is the dual mode of thinking that forms organisational members’ perceptions: the heuristic and the cogitative (Taleb, 2010). Most organisational communication theories are based on the paradigm in which receivers of information process that information in a rational way, while research in the field of neurobiology (Lehrer, 2009) indicates that rationality is dominated by emotions. This dominant cognitive perspective has its origin in Plato’s view of the rational brain as the charioteer who controls two horses; a well-bred and thus well-behaved one, whereas the emotional brain is of an ignoble breed and is thus an obstinate one. With this metaphor, Plato (1995) divided the mind into two spheres: a rational and an emotional one. The charioteer, who represents the mind, is seen as torn between reason and emotion. Recent research in the field of neurobiology (see for example: Damasio, 1994; Schwartz and Begley, 2002; Bechara and Damasio, 2005; Lehrer, 2009) proves that Plato’s view of a rational brain was wrong and with him the majority of the twentieth century scientists who based their hypothesis on the premise that human beings interpret, decide and act based on a pure cogitative processes. According to Gilkey and his colleagues we cannot even make strategic and tactical management decisions without being influenced by our emotions (Gilkey et al., 2010). If we link this to the theory of affect heuristics

(Slovic et al., 2002), and try to picture it in organisations, the burning question is how communication can influence this emotional process in a way to alter existing perceptions of present risks among its members?

The third difficulty is that organisational members are constrained to well-established, ingrained schemas (Labianca et al., 2000; Balogun and Johnson, 2004). Due to these existing schemas, the scattered information from multiple sources, and the inability to process that information through purely cognitive reasoning (Lehrer, 2009), organisational members form inaccurate perceptions of their organisation and environment (Mezias and Starbuck, 2003). Furthermore, risk perception and risk communication are linked to a specific cultural context in which hazards are framed (Dake, 1992). However, most research on risk perception and risk communication ignores this cultural context in which hazards are framed and debated (Dake, 1992; Harvey et al., 2002).

These findings should have a significant impact in the way organisations deal with communication in general, and risk communication in particular. If we assume that existing perceptions prohibit organisational members from processing information in the intentional way of the sender, the impact on safety behaviour might be disastrous. Therefore, understanding the relationship between risk communication and risk perception in organisations is of the utmost importance in order to drive appropriate safety behaviour.

1.3.5 Risk communication

A first observation is that the literature on risk communication is heavily focused on potential risks in the environmental, public health, and technological domains, and how to convince, influence or discuss these topics with an external audience. However, when it comes to communicating risk in organisations with the intention of influencing safety behaviour of the workforce, very little empirical research has been conducted (Conchie et al., 2006, p. 1098). Two of the world's leading analysts of risk, risk perception, and risk communication, Vincent Covello and Paul Slovic, predominantly focus on the impact of communication on risk perception among civilians in general, but not

on organisational members in particular (e.g., Covello et al., 1987; Slovic, 2000; Slovic et al., 2002, Covello and Wolf, 2003; Slovic, 2010).

A second observation is that communication in risk literature is dominantly perceived as "a tool utilized to represent a subjective interpretation of an external and objective reality" (Coan, 2002; p. 233) or "to maintain an organisation's image" (Coombs, 1995, p. 448). These views are based on theories such as Michael Porter's seminal "Five Forces Model" (Porter, 1980) that is based on a control view of the environment (Kumar and Becerra-Fernandez, 2007) in which information and communication technologies are seen as strategic tools to control staff and risks. From an interpretivist point of view, communication is not a tool owned by an organisation to control people or to protect its image or reputation, but rather a process owned by internal and external stakeholders who construct an interpretation of their relation with that particular organisation through dialogue and sensemaking (Boden, 1994; Mumby and Clair, 1997). Christensen and his colleagues describe this as "the co-construction of communicated meaning" (Christensen et al., 2005, p. 165).

This brings us to a third scrutiny in the literature: a divide in opinion on how to communicate about risk. Lay people judge risk perceptions in qualitative terms based on gut feelings and emotions (Slovic, 2010), while risk assessment experts use quantitative expressions of the hazardous impact of certain risks (Leiss, 2004). In other words, civilians and experts use different criteria and often a different language to judge the same facts. This feeds the debate about risk communication strategies, involvement of stakeholders in the risk evaluation process, and the flow of information concerning risk, and has eventually resulted in two very different perspectives on risk management and risk communication (Gurabardhi et al, 2005). Some scholars see risk communication basically "to revolve around one party trying to get another party to accept a representation of a hazard" (Breakwell, 2007, p. 130) by means of transferring information. This group constitutes the so-called "traditional technical view" in risk communication (Gurabardhi and Gutteling, 2002, p. 425). The other group, the so-called "democrats", look at risk communication as a

constructive exchange of information between all the actors involved in the risk process in order to reach an open, clear, and honest dialogue (Gurabardhi and Gutteling, 2002, p. 422). The argument that pleads for the democratic approach to risk communication is that many people do not have the knowledge and expertise to evaluate and understand large numbers. The result is that people become insensitive as the numbers linked to certain risks get larger. According to Slovic this can be explained by the fact that numbers fail to trigger emotions and feelings necessary to motivate action (Slovic, 2010, p. 69).

This raises the question whether this democratic view on risk communication is recommendable as well in complex interactive and tightly coupled organisations? One can presume that organisational members who received appropriate training and have experience with this have a certain level of knowledge to interpret numbers and quantitative information. Therefore the need for a deeper understanding of the role and design of risk communication in organisations is required.

1.4 Conclusion

Based on the insights in the domains of risk, perception and communication that emerged from the literature, and based on my own experience as a practitioner in the field of risk and crisis communication, the following implications have emerged:

- The conclusions made by the theory of affect heuristic might be applicable in organisational settings as well. However, there might be other rules, restrictions, or mechanisms in place that impact risky decision-making processes,
- Organisational communication in general, and communication about risk in particular, might impact the organisational members' perception process and can help them make more conscious decisions concerning certain risks,
- Mindful organisations, as described by HRO, attribute a key role to the design of communication structures,

- The so-called ‘democratic view’ on risk communication is very much in line with the notion of ‘deference to expertise’, the fifth principle of HRO.

These implications are the basis for the research question and the questions that will be used to systematically review the literature on risk communication and risk perception in complex interactive and tightly coupled organisations, while being vigilant for the specific cultural context in which hazards are framed and debated (Dake, 1992; Harvey et al., 2002).

In the next chapter I will introduce the methodology used for the systematic review of the literature.

2 METHODOLOGY

2.1 Introduction

In chapter I will first describe the review objectives, present the review questions, and introduce the review process and protocol as described by Tranfield et al. (2003). Then I will explain how I decided on the inclusion and exclusion criteria for use with full text papers, along with the quality appraisal criteria for all selected papers. Finally I will give a detailed description of the search process itself, based on all the inclusion/exclusion criteria and the quality appraisal criteria.

2.2 Review objective

The objective of this systematic review (SR) is to conduct a critical review of a body of literature concerning the relationship between risk communication and risk perception in complex interactive and tightly coupled organisations in order to develop a reliable knowledge base which aims to serve both academic and practitioner communities (Tranfield et al., 2003, p. 220). The desired outcome is to uncover what is known and unknown about the chosen topic, based on existing theories, empirical research texts and policy texts.

As stated in the introduction chapter, there is little empirical research on the specific mechanisms or moderators that might influence the relationship between risk communication and risk perception among staff in complex interactive and tightly coupled organisations. While this question might be worthwhile from an academic point of view, a practitioner community might be eager to know how risk communication can impact staff behaviour. Therefore, a closer look at the context, the interventions, and the mechanisms that influence or impact the relationship between risk communication and risk perception in these specific types of organisations is recommended for a systematic review, based on the following research question:

"What is the relationship between risk perception and risk communication in complex interactive and tightly coupled organisations?"

To examine the literature rigorously, the so-called 'CIMO-logic' (Denyer et al., 2008) was applied as a way to synthesise and structure the existing literature. In an attempt to offer more solution-oriented or prescriptive knowledge to increase relevance for practice in management science, Denyer and his colleagues (2008) offer a design proposition based on synthesising previously published research. The CIMO-logic involves "a combination of a problematic Context, for which the design proposition suggests a certain Intervention type, to produce, through specified generative Mechanisms, the intended Outcome(s)" (Denyer et al., 2008, p. 393). Table 2-1 illustrates the four components of the CIMO-logic as described by Denyer et al. (2008, p. 397).

Component	**Explanation**
Context (C)	The surrounding (external and internal environment) factors and the nature of the human actors that influence behavioural change. They include features such as age, experience, competency, organisational politics and power, the nature of the technical system, organisational stability, uncertainty and system interdependencies. Interventions are always embedded in a social system and, as noted by Pawson and Tilley (1997), will be affected by at least four contextual layers: the individual, the interpersonal relationships, institutional setting and the wider infrastructural system.
Interventions (I)	The interventions managers have at their disposal to influence behaviour. For example, leadership style, planning and control systems, training, performance management. It is important to note that it is necessary to examine not just the nature of the intervention but also how it is implemented. Furthermore, interventions carry with them hypotheses, which may or may not be shared. For example, 'financial incentives will lead to higher worker motivation'.
Mechanisms (M)	The mechanism that in a certain context is triggered by the intervention. For instance, empowerment offers employees the means to contribute to some activity beyond their normal tasks or outside their normal sphere of interest, which then prompts participation and responsibility, offering the potential of long-term benefits to them and/or to their organisation.
Outcome (O)	The outcome of the intervention in its various aspects, such as performance improvement, cost reduction or low error rates.

Table 2-1 CIMO-logic: the components of design propositions (taken from Denyer et al., 2008; p. 397)

Linking this CIMO-logic to my research question offers the following review questions:

1. How does context influence the relationship between risk communication and risk perception in complex interactive and tightly coupled organisations?
2. What interventions influence the relationship between risk communication and risk perception in complex interactive and tightly coupled organisations?
3. What mechanisms are triggered by an intervention in a certain context that influence the relationship between risk communication and risk perception in complex interactive and tightly coupled organisations?
4. What is the outcome of these interventions and mechanisms in a certain context on the relationship between risk communication and risk perception in complex interactive and tightly coupled organisations?

The research question and the review questions can be illustrated in the figure below (Figure 2-1).

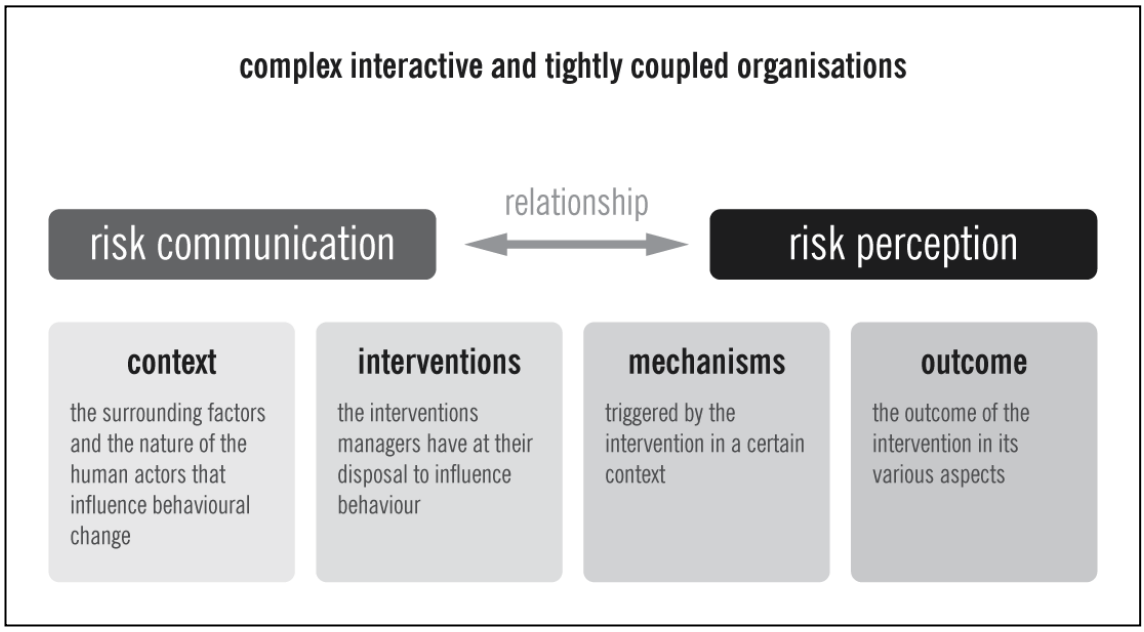

Figure 2-1 Research question underpinned by CIMO-logic

It is noteworthy that Denyer and his colleagues used published research in the field of high-reliability organisations (HROs) to illustrate the design of the so-called ‘CIMO-logic’.

In this SR the focus will be on the relationship between risk communication and risk perception in complex interactive and tightly coupled organisations. By systematically reviewing the literature I want to uncover what is already known about this relationship.

The focus is on the individual level; thus, both the sender and the receiver of the communication who interpret formalised communication that eventually turn into artefacts such as procedures, safety rules, guidelines, or codes of conduct (Elliott and Macpherson, 2010). Referring to Slovic (2000) risk is not something tangible, but rather a concept that is constructed in the mind, perception and emotion of every individual. Therefore I consider perceptions primarily as individual constructions. Even though meanings and perceptions can be influenced by and created through interaction, every individual goes through a personal sensemaking process (Thomas et al., 1993; Weick, 2001) in order to create an individual meaning that might be shared with a group and can be adapted or readapted on an individual basis. Although the level of analysis will be on the individual organisational member, I will not neglect the insights the literature offers on the interventions, mechanisms, and effects of risk communication on group level or organisation level. The rationale is that teams, as well as organisations, consist of individuals who might affect individual and group perceptions.

Furthermore, I only consider those risks that are directly linked to the day-to-day activities of an organisation, and where a perception of a plausible risk might have an impact on the processes, systems, products, or services of that organisation. Risks such as terrorism, pandemics, and natural hazards (e.g., earthquakes, storms, floods, etc.) are not in the scope of this SR. Nor are the perceptions of risk communication to an external audience (e.g., civilians, neighbours) the focus of this SR.

2.3 Systematic review process

This systematic review is conducted using the methodology as described by Tranfield et al. (2003, p. 214), and has been outlined in Table 2-2.

Stage I – Planning the review
Phase 0 - Identification for the need for a review Phase 1 - Preparation of a proposal for a review Phase 2 - Development of a review protocol
Stage II – Conducting a review
Phase 3 - Identification of research Phase 4 - Selection of studies Phase 5 - Study quality assessment Phase 6 - Data extraction and monitoring progress Phase 7 - Data synthesis
Stage III – Reporting and dissemination
Phase 8 - Report and recommendations Phase 9 - Getting evidence into practice

Table 2-2 The stages of a systematic review (taken from Tranfield et al., 2003; p. 214)

Stage I of the SR-process, the planning of the review, was finished and signed off by the supervisory review panel before I started with Stages II and III.

In the following sections I will discuss the identification of the keywords and search string, the selection of the sources and the databases, as well as the assessment criteria.

2.4 Review protocol

A review protocol is “a plan that helps to protect objectivity by providing explicit descriptions of the steps to be taken” (Tranfield et al., 2003, p. 215). In this

section I will elaborate on the outlines for conducting the systematic review and the different steps I took in the review process.

2.4.1 Review panel

The purpose of the review panel is to provide expert guidance on the protocol for the review, the appropriateness of selected papers, and an overall reflective consulting on the process. Besides the review panel, who are all experts in the areas of methodology and theory, I could also rely on both my cohort leader, Dr Carlos Mena, for practical issues, and the social science information specialist of the Kings Norton Library, Mrs Heather Woodfield, for guidance regarding the search engines to find the right documents. All panel members are from the Cranfield School of Management, and have been described in Table 2-3.

Name	Organisation	Expertise
Prof. Donna Ladkin	Cranfield SOM	Leadership and ethics, Lead supervisor
Dr. Colin Pilbeam	Cranfield SOM	Panel Chair
Prof. David Denyer	Cranfield SOM	Systematic Review specialist, Panel member
Dr. Ruth Sealy	Cranfield SOM	CPD, Panel member
Dr. Carlos Mena	Cranfield SOM	Cohort leader, DBA cohort 09-13
Mrs. Heather Woodfield	Kings Norton Library, Cranfield University	Social science information specialist

Table 2-3 List of members of the review panel

2.4.2 Consultation groups

According to the SR-requirements, as stated by Tranfield et al. (2003, p. 214), I formed two consultation groups; one including both practitioners and academics working in the field of risk and crisis communication, and one including academics and alumni from HEC (Paris) and Saïd Business School (Oxford).

The first consultation group meets twice a year at the so-called ‘PM expert meetings’ (PM refers to my company’s name). These are meetings with practitioners in the field of risk and crisis communication, and the field of risk

and safety management. The participants belong to different kinds of organisations, such as hospitals, security services, the food industry, and (petro)chemical industries. Other participants are academia in the broad field of organisational behaviour, and some in the field of risk and crisis communication. A final component of this expert group are experts in these fields working as independent consultants or as advisors to legislative bodies. At these sessions work in progress is presented and discussed. The first meeting was held on 4 March 2011 at the Royal Military Academy in Brussels, where I met fellow researchers and faculty members in the field of risk and crisis communication.

The second consultation group is 'the Change Leaders', an alumni group from the HEC (Paris) and Saïd Business School (Oxford) Masters Programme on change management. Twice a year this group meets for a couple of days to reflect on certain themes in the field of change. However, a full day is used to present recent or ongoing research. As faculty members of both universities support these venues, this consultation group forms an excellent sounding board to discuss possible ways in the systematic review process with peers and HEC and Oxford faculty.

I was privileged to present results of the scoping study and an initial draft of the systematic review protocol. Members of both consultation groups actually suggested academic and practitioner oriented readings in the field of risk communication to me.

2.4.3 Sources, search terms, and databases

In this section I will discuss the protocol plan for literature sources, the search terms, and the selected databases.

2.4.4.1 Literature sources

As a practitioner in the field of risk and crisis communication I am obliged by my clients, who run highly reliable operations on a global scale, to have extensive knowledge of all key books and major publications, both practitioner and academic oriented, in my domain of expertise. As we often conduct research

projects for legislative bodies (both on a local and European level) and commercial organisations, a profound knowledge of the available literature and a broad range of sources is a condition *sine qua non*.

In 2010 I co-authored a book on risk and crisis communication (Marynissen et al., 2010). The theoretical background for this practitioner-oriented book was discussed and aligned with Prof. Jan Van den Bulck and Prof. Jan Gutteling, both highly respected academics in the field of (risk) communication (Marynissen et al., 2010, p. 200).

Based on this background knowledge, I identified a broad range of sources of literature as a starting point for my review. These sources include broad categories such as academic research, academic and practitioner-oriented books, as well as practitioner-oriented articles and websites (see Table 2-4). Some literature was recommended by members of the consultation groups, other sources derived from the scoping study. These sources gave me a good overview of the current topics and discussions in the field of risk communication and risk perception. A detailed list of secondary sources of published academic research and practitioner-oriented insights is presented in Appendix A.

Sources	**Value to the review**
Academic journals	Primary source of published academic research
Academic books	Secondary source of published academic research
Conference papers and proceedings	Primary source of unpublished academic research
Practitioner research reports and papers	Primary source of practitioner oriented insights and data

Table 2-4 Broad category of sources of literature

A search of conference programmes over the past 3 years (2008-2011) from “Academy of Management”, “Society for Risk Analysis”, and “Society for Industrial and Organizational Psychology” was conducted to locate unpublished studies.

Based on the references published in academic and practitioner-oriented books, I identified a number of key academic journals that are relevant sources of literature in the fields of risk communication and risk perception. These journals are presented in Table 2-5. A full list of the academic journals that offered articles for this systematic review is presented in Appendix B.

Journal	Rating[5]
Academy of Management Journal	4
Academy of Management Review	4
Group and Organization Management	3
Journal of Applied Psychology	4
Journal of Risk Research	None
Journal of Safety Research	None
Management Science	4
Risk Analysis	3
Safety Science	2

Table 2-5 Key sources of literature in the fields of risk communication and risk perception

My decision to focus on academic research, and not on academic books, nor on published practitioner research and books resulted from two reasons: a limitation of time, and a quality concern. There simply was not enough time in the research project to evaluate and assess the vast amount of literature to find relevant pieces that are additive to knowledge captured in the academic literature. Furthermore, none of the consulted books (see Appendix A) specifically cover the field of risk communication in complex interactive and tightly coupled organisations. They all deal with risk management, or risk communication with civilians. And when it comes to the quality concern, the practitioner content in the domain of risk communication is dispersed and dominantly based on gut feeling, assumptions, and dodgy interpretations of consultancy work.

[5] According to Journal Recommendations for Academic Publications, Cranfield University SoM, Eighth Edition, April 2011.

2.4.4.2 Search terms

In order to find the right keywords, I divided my SR-question into four domains:

1. Risk
2. Communication
3. Perception
4. Organisation

For each of these domains, I went back to the literature I used for the scoping study, and collected those words that could be relevant. I also selected words referring to various domains I did not include in the review, such as terrorism, climate change, pandemics, et cetera. Both the search terms and the words referring to domains I excluded were combined in an overall search string that contains four AND-strings, and one AND NOT-string. This search string is listed below in Table 2-6.

[risk]
AND
[communicati* OR informati*]
AND
[*perception OR sens* OR interpret* OR schema OR (mental AND model)*]
AND
[*organi* OR group OR team OR (high AND hazard) OR (high AND reliabilit*) OR seveso*]
AND NOT
[*flood OR pandemic OR financ* OR market OR climat* OR stock OR gambl* OR influenza* OR natur* OR consumer OR comput* OR software OR internet OR medic* OR cancer OR HIV OR politic* OR terror*]

Table 2-6 Overall search string

A suggestion, made by the panel chair, was to adapt the search string on organisation. His rationale was that because the review is about organisations that are highly reliable, therefore it would be more appropriate to use “AND” instead of “OR”. However, by changing this search string into *[organi* OR group OR team OR (high AND hazard)* ***AND*** *(high AND reliabilit*) OR seveso]* only one scholarly journal article appeared in the ProQuest database. A second attempt, changing the search string into *[organi* OR group OR team OR **(**(high AND hazard)* ***AND*** *(high AND reliabilit*)**)** OR seveso]* resulted in 189 scholarly journal articles, whereas my initial search resulted in 195 scholarly journal articles. Therefore I decided to keep the initial overall search string, as it

resulted in a slightly higher number of scholarly journal articles, and thus a higher probability for finding the maximum amount of useful literature in this domain under review.

Subsequently, I accomplished the search process in four steps:

1. I entered the search string to interrogate the different databases (see: "2.4.3 Sources, search terms, and databases"). These raw results are illustrated in Table 2-7,
2. I searched the full texts where available, otherwise I used title and abstract, and selected scholarly journals (I will expand on this in 2.4.4 Assessment criteria),
3. When the search results exceeded 300 hits using full text, the search was limited to title and abstract only,
4. Relevant articles were downloaded or requested from the Cranfield University library.

Database	Results
AIB/Inform	195
EBSCOhost	18
Science Direct	75

Table 2-7 Raw results of interrogating the databases

The search process was extended to citations and references of the selected articles. This will be discussed in a later section (see: "2.5 The search process").

2.4.4.3 Databases

Several online databases are important sources of relevant literature and a way to access aggregate data from the other sources. The search engines I used for this review are:

- ProQuest: ABI/INFORM Dateline, ABI/INFORM Global, ABI/INFORM Trade & Industry
- EBSCOhost Research Database: Business Thesaurus, Environmental Thesaurus, ERIC-Thesaurus

- ScienceDirect: *(excluding Journal of Adolescent Health, Midwifery, Child Abuse & Neglect, Journal of Clinical Epidemiology, Drug and Alcohol Dependence, Nurse Education Today, International Journal of Drug Policy, Journal of Business Venturing, Journal of Aging Studies, and excluding the topics: midwife, road safety, physically abused, postpartum depression, pregnant adolescent, pregnant woman, primiparous woman, child, organic farming, platform migration")*
- Web of Knowledge
- Cranfield University library catalogue: primary source of Cranfield University's collection

These databases were selected because they are all top aggregators of academic research.

2.4.4 Assessment criteria

The initial broad selection criteria for use with titles and abstracts of papers retrieved from searches were based on the following inclusion and exclusion criteria:

Inclusion: articles in peer reviewed journals, book chapters, conference papers, and unpublished research:

- Risk perception and risk communication are linked to a specific cultural context in which hazards are framed (Dake, 1992). I will therefore focus on one culture, in particular the literature from Western Europe and North America,
- Based on literature that offers insights, models, theory, or empirical research,
- Based on research in organisations with complex interactive and tightly coupled systems,
- Literature focused on intra-organisational communication and risk.

Exclusion:

- Articles published before 1990, as the majority support a one-way risk communication flow (Gurabardhi et al., 2005),

- Articles that deal with climate issues, gambling, software or hardware risks, medical or pharmaceutical risks, or health issues,
- Literature on crisis management, crisis communication, (Crisis) PR, public affairs, inter-organisational risk management and communication, crisis handling, crisis response strategy, business continuity management, risk management, contingency planning, cyber risk, terrorism.

Based on these initial criteria, a list of selection criteria for use with full text papers was elaborated. This list is presented in Table 2-8. The literature obtained from the databases as explained earlier was assessed against the above selecting criteria using a simple scoring template:

- Yes: the inclusion criteria are fully met (value=3)
- Somewhat: the inclusion criteria are partially met (value=2)
- No: the inclusion criteria are not met (value=1)
- Not Applicable: the inclusion / exclusion criteria are not applicable for this paper (value=0)

Papers with 0 or 1 scores were excluded from further review.

Search term	**Inclusion**	**Exclusion**
Risk	Risks as the unit of analysis	Risk as peripheral variables, not linked to organisational operations or environment (i.e., gambling, pandemics, etc.)
Communication	Communication as the unit of analysis	Telecommunications
Information	Transfer of information by means of any form of communication	Not related to organisational communication
Perception	Perception as the unit of analysis	Not perception coloured by religion
Sensemaking	Mental scanning of the environment for clues, interpretation, and decision for taking action and performance	Understanding without a link to undertaking action
Interpretation	Sensemaking	Not related to linguistics
Schema	Interpretation	Not related to technical plans
Mental model	Interpretation	Not related to technical plans
Organisation	The organisation as the focus of analysis	Not related to projects
Group	The group as the focus of analysis	Not related to projects

Team	The team as the focus of analysis	Not related to projects
High hazard	Related to high organisational risks	Not related to commodities
High reliability	Related to high organisational risks	Not related to IT
Seveso	Related to high organisational risks and EU-directive 82/501/EEC	Not related to the Italian town called Seveso

Table 2-8 Selection criteria for use with full text papers

2.4.5 Quality assessment

According to Wallace and Wray a critical approach to the reading of a journal article or book "is essential if we are to assess the value of the work it reports" (Wallace and Wray, 2006, p. 4). In order to base this review on "the best-quality evidence" (Tranfield et al., 2003, p. 215), I applied the following quality appraisal criteria for all research papers that passed the assessment criteria and the selection criteria for use with full texts (as described in 2.4.4):

Theory: Does the paper test, create, or extend theory to the relationship between risk communication and perception in a meaningful way? Does the study support or improve my understanding of an existing theory? Are major concepts clearly elaborated or explained?

Literature review: Does the paper cite appropriate literature and provide proper credit to existing work on the topic?

Method: Do the sample, measures, methods, observations, procedures, and statistical analyses ensure internal and external validity? Are the statistical procedures used correctly and appropriately? Are the major assumptions of the statistical techniques reasonably well met?

Integration: Does the study provide a good test of the theory and hypotheses, or sufficient empirical grounds for adding on to existing theory or building new theory? Is the chosen method (qualitative or quantitative) appropriate for the research question and theory?

Contribution: Does the paper make a new and meaningful contribution to the literature in terms of theory, empirical knowledge, or management practice?

All the papers that are used in this systematic review are evaluated according to this quality appraisal. They are described in Appendix D.

2.4.6 Conclusion

As I am looking for a specific body of literature, the one on how risk communication has an impact on employees' risk perception, the number of world leading (4 star rated) or internationally excellent (3 star rated) journals in the field of risk management or risk communication is rather limited. Therefore I decided to broaden the scope to other peer-reviewed journals as well. The *Journal of Risk Research*, for example, is exemplary for a peer-reviewed but non-rated academic journal. This journal published a number of articles by highly respected academics in the field of risk perception and risk communication over the last decade (e.g., Gurabardhi et al, 2005; Specht et al, 2006; Conchie and Burns, 2009). I therefore decided to include a limited number of articles published in non-rated peer reviewed journals in this review.

2.5 Search process

To identify the most relevant literature in an unbiased way (Tranfield et al., 2003) I conducted the search process in a very systematic way. The different steps in this process are illustrated in Figure 2-2, and have been described in more detail below.

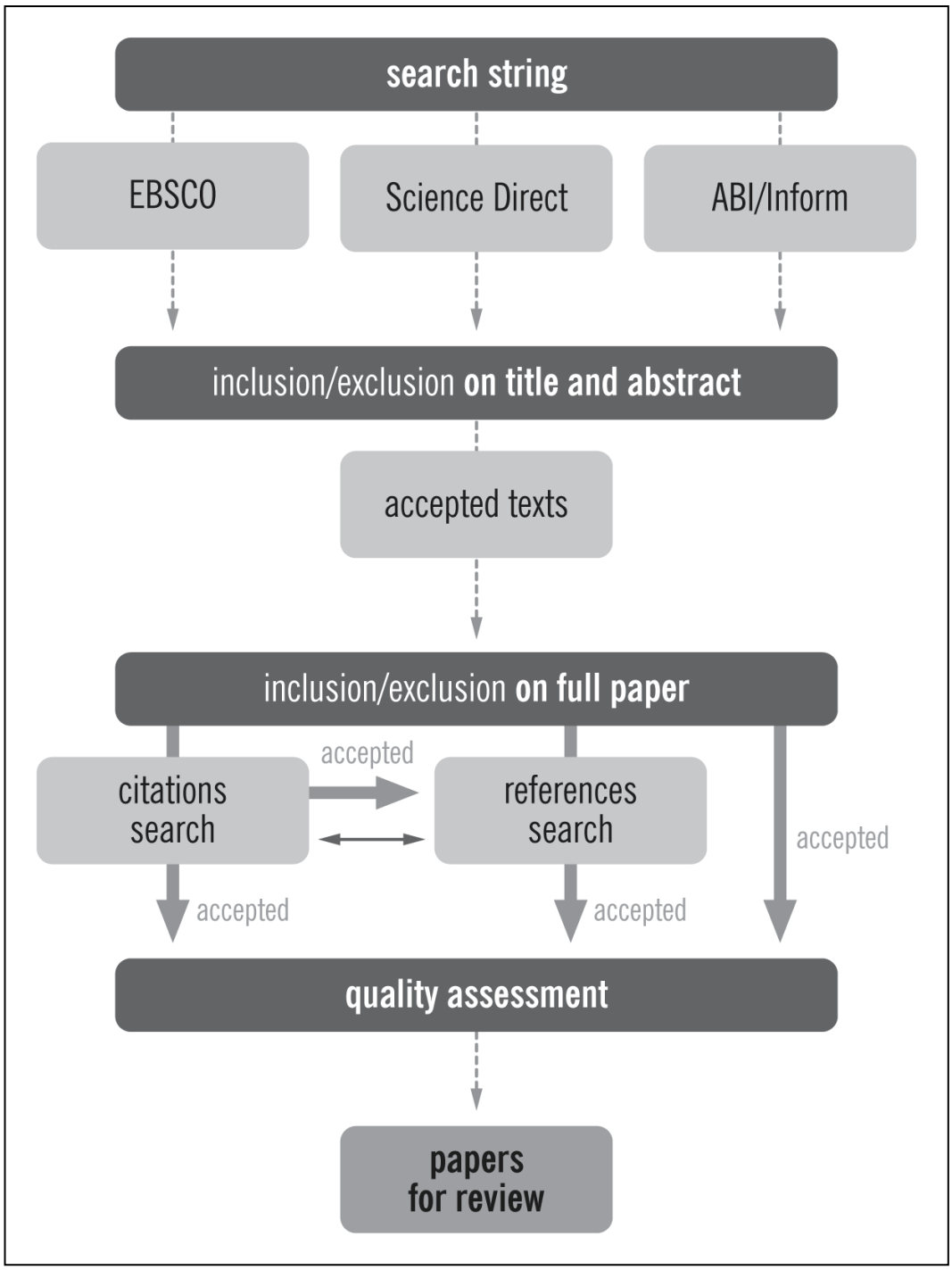

Figure 2-2 Search process

- The overall search string, as described in Table 2-6, was entered in three databases: EBSCOhost, Science Direct, and ABI/Inform,
- Based on the inclusion/exclusion criteria, as described in 2.4.4, the appropriate texts were selected based on title and abstract.

- The literature that passed these inclusion/exclusion criteria ('Accepted texts') went through a second round of evaluation based on the full content of the paper. For this second evaluation, the selection criteria for use with full text papers (as presented in Table 2-8) were applied.
- For the literature that passed these inclusion/exclusion criteria, the Web of Knowledge database was used to conduct a search of all the citations. The same selection criteria for use with full text papers were applied to review the papers produced by this citation search. In the event the Web of Knowledge database did not include the paper, I used Google Scholar to identify the citations.
- For the literature that passed the selection criteria for use with full text papers, and for the literature produced by the citation search which was accepted, a review of all the references was conducted. In the event that the Web of Knowledge database did not include the paper, the references were reviewed manually.
- All the literature from the "citation search" and the "references search" that passed the selection criteria for use with full text papers went through this citation and reference search process until no papers confirming the inclusion criteria appeared.
- The texts that passed through all searches were subsequently assessed using the quality appraisal criteria as described in section 2.4.5.
- The texts that passed the quality appraisal criteria were included in the review. This list is described in Appendix C.
- Once a piece of literature was considered relevant based on the selection criteria and the quality assessment, it was loaded into the EndNote reference management software.

This search process provided a total set of 26 texts to review and synthesise. An overview of the search results is illustrated in Table 2-9.

Search action	Description	Reviewed	Selection based on title and abstract	Final selection based on full text	Selection rate
1	AIB/Inform	195	9	4	2.1%
2	EBSCOhost	18	2	2	11.1%
3	Science Direct	75	6	2	2.7%
4	Citation search	907	15	10	1.1%
5	Reference search	1,761	16	8	0.5%
Total		**2,956**	**48**	**26**	**0.9%**

Table 2-9 Overall search results

2.6 Results

The 26 papers that came out of the search process can be broken down into the following categories:

- Theory building literature: 6 papers
- Literature review: 2 papers
- Policy literature: 1 paper
- Empirically-based literature: 17 papers
    - 12 based on quantitative empirical research
    - 4 based on qualitative empirical research
    - 1 based on mixed methods (a combination of quantitative and qualitative empirical research)

Table 2-10 gives an overview of the 17 selected empirically-based research papers in terms of authors, title, publishing date, the industry as a unit of analysis, geography, and method of data collection. A full overview of all the selected papers is presented in Appendix C.

	Author(s)	Title	Publication	Year	Industry	Geography	Method of data collection
1	Klein et al	Organizational culture in high reliability organizations: An extension	Human Relations	1995	Air traffic control center and a nuclear power plant	USA	Combination of quantitative (survey) and qualitative (field observations) methods
2	Sitkin and Weingart	Determinants of risky decision-making behavior: A test of the mediating role of risk perceptions and propensity	Academy of Management Journal	1995	Not specified	USA	Quantitative - Study 1: MBA students Study 2: Undergraduate students
3	Sauer	Communicating risk in a cross-cultural context: A cross-cultural comparison of rhetorical and social understanding in US and British mine safety training programs	Journal of Business and Technical Communication	1996	Mining industry	UK and USA	Qualitative analysis of printed communication
4	Grote and Künzler	Diagnosis of safety culture in safety management audits	Safety Science	2000	Petrochemical industry	USA and UK	Quantitative questionnaires
5	Houghton et al	No safety in numbers: Persistence of biases and their effects on team risk perception and team decision making	Group and Organization Management	2000	Not specified	USA	Quantitative questionnaires (MBA students)
6	Harvey et al	The effectiveness of training to change safety culture and attitudes within a highly regulated environment	Personnel Review	2001	Nuclear processing plant	UK	Quantitiative questionnaires
7	Harvey et al	An analysis of safety culture attitudes in a highly regulated environment	Work and Stress	2002	Nuclear processing plant	UK	Quantitiative questionnaires
8	Zacharatos et al	High-performance work systems and occupational safety	Journal of Applied Psychology	2005	Manufacturing, telecom and petroleum industry	Canada	Quantitiative questionnaires
9	Burns et al	Explicit and implicit trust within safety culture	Risk Analysis	2006	Gas plant	UK	Quantitative questionnaire and priming task
10	Conchie and Donald	The role of distrust in offshore safety performance	Risk Analysis	2006	Offshore gas plant	UK	Quantitative servey
11	Michael et al	Production supervisor impacts on subordinates' safety outcomes: An investigation of leader-member exchange and safety communication	Journal of Safety Research	2006	Wood products manufacturing	USA	Quantitative servey
12	Conchie and Burns	Trust and risk communication in high-risk organizations: A test of principles from social risk research	Risk Analysis	2008	Health	UK	Quantitative servey of 393 student nurses
13	Dillon and Tinsley	How near-misses influence decision making under risk: A missed opportunity for learning	Management Science	2008	Aerospace	USA	Quantitative servey among students and NASA staff
14	Conchie and Burns	Improving occupational safety: using a trusted information source to communicate about risk	Journal of Risk Research	2009	Construction	UK	Quantitative servey
15	Lombardi, et al	Factors influencing worker use of personal protective eyewear	Accident Analysis and Prevention	2009	Manufacturing, construction, and service/retail industry	USA	Qualitative research based on 7 focus groups
16	Kath et al	Safety climate dimensions, leader–member exchange, and organizational support as predictors of upward safety communication in a sample of rail industry workers	Safety Science	2010	Canadian Pacific Railway	Canada	Quantitative servey based on a five level Likert-type questionnaire
17	Hambach et al	Workers' perception of chemical risks: A focus group study	Risk Analysis	2011	Chemical industry	Belgium	Qualitative research based on 7 focus groups with blue-collar workers

Table 2-10 Overview of the selected empirically-based research papers

Although all the selected papers deal in some way with risk communication in organisations, it is remarkable to observe how the authors underpin their hypothesis and arguments with findings that stem from theory building literature or empirical research in the domain of risk communication with, and risk perception of, civilians.

A second observation is that only four papers (Klein et al., 1995; Grote and Künzler, 2000; Harvey et al. 2001; Hambach et al., 2011) fully cover the research question, i.e., they deal with the impact of risk communication on risk perception in complex interactive and tightly coupled organisations. Although the remaining papers give answers to one or more review questions as well,

they are predominantly focused on other aspects of the domains under scrutiny, such as:

- the role of risk perception in risky decision-making behaviour (Sitkin and Pablo, 1992; Sitkin and Weingart, 1995; Dillon and Tinsley, 2008; Ganzach et al., 2008),
- communicating risk in a cross-cultural context (Sauer, 1996; Specht et al., 2006),
- the role of trust in risk communication and in the construct of risk perception (Burns et al., 2006; Conchie and Donald, 2006; Conchie and Burns, 2008),
- the role of training as a communication tool (Nævestad, 2008),
- the importance of communication and leadership in creating a safety culture that has a positive impact on risk behaviour (Zacharatos et al., 2005; Michael et al., 2006; Nævestad, 2009; Beus et al., 2010; Kath et al., 2010).

In the next section I will present the initial answers to the review questions that derive from the search process.

2.7 Initial findings of the review process

A first analysis of all the 26 selected papers offered ample themes that fit the CIMO-logic (Denyer et al., 2008). Table 2-11 illustrates these findings.

Contextual factors	Interventions	Mechanisms	Outcome
Specific (safety) culture and social influence	The role of management and trade unions in safety culture	Communicating and collaborating for safety through team working	Reduced risk perception and involvement in safety
Trust in hierarchy	Leadership style	Sensemaking and mindfulness	Mutual respect and collaborating for safety through team working
Lack of trust in hierarchy	Hierarchical communication	Heedful interrelating	High impact of communication on risk perception
Risk propensity and safety involvement	Adding people to a decision process	Individuals' information-processing biases	Employee's safety involvement

		affect risk perception and decision making	
Problem framing and problem domain familiarity	Safety training	Workers are operating collectively, developing collective rules of dealing with risk	Lower accident rate due to adjustment of risk perception
Age and experience	Safety training and learning	Awareness and sensemaking	Reliable risk perception
Linguistic, cultural and rhetorical misunderstanding	Comprehensible content of communication	Different cultural values imply different psychological contracts in relation to safety attitudes and behaviour	Adjustment of risk perception
Guilt, blame and power	Management style	Safety may be seen as a 'top-down' initiative	Risk homeostasis
Beliefs concerning level of perceived control and luck	Introducing learning and evaluation mechanisms	Avoidance of feelings of complacency and hubris	Functional distrust, mindfulness in organisation

Table 2-11 Findings of the review process based on the CIMO-logic

A remarkable observation is that all the elements found in the literature on the relationship between risk communication and risk perception perfectly fit the CIMO-logic. However, not all of the elements as presented in this CIMO-framework were offered in the same logic. In other words, bits of data captured from different papers were linked to each other to fit the CIMO-logic. This might be illustrated by "age and experience -> safety training and learning -> awareness and sensemaking -> reliable risk perception". Lombardi et al. (2009) indicated the contextual factor of age and experience as relevant for interpreting certain communications about risk in a positive or a negative way. Harvey et al. (2001) and Specht et al. (2006) offer the importance of safety training and safety learning as an intervention to counter or change this interpretation of risk communications. The mechanism that is triggered by this intervention in this specific context is more awareness of how risk might impact safety and a sensemaking process (Weick and Sutcliffe, 2007). The outcome of the intervention is a more balanced, reduced and reliable risk perception (Conchie and Donald, 2006).

2.8 Remark

Many attributions that are linked to the context, interventions, mechanisms, or outcomes of the relationship between risk communication and risk perception do not stem from empirical research. Most of the components are based on the authors' own conclusions, and are not supported by any data. Quite often the conclusions made by different authors are based on their own interpretations or insights of other scholars. Following the line of referencing, it appears that most of the claims are originally based on theoretical papers and not on findings from empirical research.

2.9 Preliminary conclusions

This systematic search process confirms the previous conclusions I made in the scoping study: little empirical research is done in the field of risk communication and risk perception in complex interactive and tightly coupled organisations. That explains why the search process resulted in relatively few papers.

Although the aim was to select highly rated academic journals, only 12 out of the 26 journal articles turned out to have "world-leading" (4 stars) or "internationally excellent" (3 stars) quality ratings based on the Cranfield School of Management Journal Rankings, Eighth Edition, April 2011. The other half of the articles stem from journals rated "internationally recognised" (4 papers), "national" (2 papers), or not rated at all (8 papers).

Due to the absence of a systematic analysis about the relationship between risk perception and effective risk communication (Conchie and Donald, 2006), I decided to include these 'low rated' and 'non rated' journal articles in this systematic review. The rationale for inclusion is that they all meet both the inclusion and exclusion criteria (see: "2.4.4 Assessment criteria") and the quality appraisal requirements (see: "2.4.5 Quality assessment").

In the next chapters I will elaborate on the findings concerning the review questions about the contextual factors, the interventions, the mechanisms and

the outcomes of the relationship between risk communication and risk perception in complex interactive and tightly coupled organisations. Key themes will be further explored and connected to other findings in the literature. The final chapter of part II of the doctoral thesis will synthesise the different findings concerning this relationship between risk communication and risk perception in complex interactive and tightly coupled organisations, its limitations, and recommendations for further research.

3 FINDINGS

3.1 Contextual factors

3.1.1 Introduction

According to Denyer and his colleagues the surrounding factors, both external and internal, and the nature of the human actors that influence behavioural change form ‘context’ (Denyer et al., 2008, p. 397). Furthermore, Denyer et al. (2008) refer to Pawson and Tilley (1997) who stated that every action or intervention is always embedded in a social system, and thus affected by four contextual layers: the individual, the interpersonal, the institutional and the wider infrastructural system.

In the light of this systematic review, context must be seen as the surrounding factors of the relationship between risk communication and risk perception in complex interactive and tightly coupled organisations. The nature of the human being(s) that influence that relationship is also an integral part of the context. These contextual factors have an impact on the way people communicate about risk, and how they perceive risk. Context does not only include certain features such as age, experience, language, or rhetoric in which communication has a specific position and role. Social systems, as well as other less tangible features such as the amount of trust among the members of the organisation and the figurative room for expressing this trust or distrust are part of the context as well. Linking back to the literature under review, safety culture, organisational culture, and cultural misunderstanding must be seen as factors that are rooted in a social system.

Examining the literature that resulted from the systematic review process, 20 out of 26 papers indicate contextual factors that might influence the relationship between risk communication and risk perception. From these 20 papers, 16 are based on empirical research. However, only nine were executed in organisations with complex interactive and tightly coupled systems, such as nuclear power plants (Harvey et al., 2001; 2002), a UK offshore (Burns et al.,

2006) and onshore gas plant (Conchie and Donald, 2006), an air traffic control centre (Klein et al., 1995), NASA (Dillon and Tinsley, 2008), or chemical companies (Grote and Künzler, 2000; Zacharatos et al., 2005; Hambach et al., 2011). One research paper (Hambach et al., 2011) used a qualitative method involving different focus groups. Two other papers that shed light on how the contextual factors might impact the relationship between risk communication and risk perception claim to be based on qualitative research methodologies such as ethnographic observations and qualitative interviews (Specht et al, 2006) or hermeneutic analysis of publications (Sauer, 1996). Although both studies offer valuable concepts and theoretical insights, they fail to uncover their methods of data gathering and analysis.

In the next sections I will discuss the literature and the findings of this review concerning the context that influences the relationship between risk communication and risk perception.

3.1.2 Review of the literature

The contextual factors that are found in the reviewed literature are presented in Table 3-1.

Contextual factors	References
Safety culture	Sitkin and Pablo (1992); Klein et al. (1995); Sauer (1996); Harvey et al. (2001); Harvey et al. (2002); Zacharatos et al. (2005); Michael et al. (2006); Burns et al. (2006); Specht et al. (2006); Conchie and Burns (2008); Dillon and Tinsley (2008); Conchie and Burns (2009); Kath et al (2010); Hambach et al. (2011)
Trust	Conchie and Burns (2008); Conchie and Burns (2009); Hambach et al. (2011)
Lack of trust	Zacharatos et al. (2005); Burns et al. (2006); Conchie and Burns (2008); Hambach et al. (2011)
Safety involvement	Sitkin and Weingart (1995); Beus et al. (2010)
Problem framing and problem domain familiarity	Sitkin & Pablo (1992); Sitkin & Weingart (1995)
Age and experience	Houghton et al. (2000); Harvey et al. (2001); Lombardi et al. (2009)
Linguistic, cultural and rhetorical misunderstanding	Klein et al. (1995); Beus et al. (2010)
Guilt, blame and power	Harvey et al. (2001); Nævestad (2008)
Beliefs concerning level of perceived control and luck	Grote and Künzler (2000); Dillon and Tinsley (2008)

Table 3-1 Contextual factors and their references

A general observation when focusing on the context that influences the relationship between risk communication and risk perception in complex interactive and tightly coupled organisations, is that the literature is heavily focused on technical risk management systems, while the literature on human risk management systems is rather scarce (Specht et al., 2006; p. 526). In the technical systems, risks are seen as mechanical causes of organisational disasters that can be prevented or not (Rijpma, 2003). The human systems, on the other hand, focus on the workers' risk-mastering activities that are rooted in safety behaviours. This debate between the two systems is basically an ontological discussion between a positivist and a constructionist view on risk and organisational safety. In a theoretical paper on organisational safety in potential hazardous operations, Rochlin argues to take into account collective as well as individual agency in the construct of a safe operation environment as an interactive, dynamic and communicative act (Rochlin, 1999; p. 1549). This notion of individual as well as a collective construction of safety culture is further developed in the work by Specht et al. (2006). They argue that workers, who are confronted with risk, refer to their own risk perception to lead collective behaviour. In other words, although a previous risk experience can act on an individual level, when employees are working together, they develop shared risk perceptions as a group (Specht et al., 2006; p. 526), and thus, social influence is definitely a contextual factor. This link between individual and collective risk perception, and the activation of behaviour, is what Specht and his colleagues call 'cultural process'. The model they present is called 'Human Risk Management System' (Specht et al., 2006; p. 537) and basically refers to the context that influences the relationship between risk communication, risk perception, and safety behaviour.

The notion of Specht and his colleagues of a cultural process between individual and collective risk perception, and the activation of behaviour (Specht et al., 2006; p. 526), are partly in line with Pawson and Tilley's 'contextual layers' as mentioned earlier (Pawson and Tilley, 1997). Specht et al.'s (2006)

'Human Risk Management System' indicates a social context in which interventions and mechanisms are embedded and thus influence risk perception, human behaviour and workers' risk mastering activities. Their review resulted in a classification of the cultural process in which risk communication could be driven by an organisation through information and training (Specht et al., 2006, p. 530), and contains four processes:

- Social representations: refers to a human environment where people are linked to each other by various interactions such as language, history, regulations, etc.
- Group interactions: refers to groups' mutual and reciprocal influences (i.e., a combination of individual and collective mechanisms), such as values, practices, rules of behaviour.
- Organisational learning: refers to the processes organisations implement to manage knowledge and *savoir-faire*.
- Team working: refers to the social reality of work. In other words, even isolated, individuals depend on each other, and by doing so they develop collective rules.

This classification of the cultural process, in which workers who are confronted with risk refer to their own risk perception to lead their behaviour (Specht et al., 2006), supports my definition of risk. As stated in the introduction chapter, I define risk as socially constructed, and thus both an individual and a collective interpretation of a concept that is based on the chance of losing or gaining something, which can individually or collectively trigger associated perceptions that might have an impact on individual, group, institutional or societal level.

A second observation is that almost all of the research papers focusing on risk communication and risk perceptions in complex interactive and tightly coupled organisations denote safety culture as a key feature of context. According to Harvey and his colleagues safety culture involves perceptions, attitudes and behaviours of individuals within an organisation (Harvey et al., 2002, p. 19). It could be argued that 'attitude' is the mechanism that is triggered by a certain intervention (which is 'behaviour'), which results in a specific outcome

(perception). Therefore, in this context, safety culture might be seen as the breeding ground for interventions, mechanisms and outcome.

Another component in the literature is the focus on safety culture in which communication is predominantly seen as a tool to convince the workforce (Harvey et al., 2002; Michael et al., 2006), an element in diagnosing the safety culture (Grote and Künzler, 2000; Beus et al., 2010), or as a key element in organisational learning or training programmes (Sauer, 1996; Harvey et al., 2001). The exceptions here are empirical research by Kath et al. (2010) and Hambach et al. (2011) who focus on analysing the communication itself. Kath and her colleagues (2010) examined the upward safety communication rail industry workers in the USA apply and its positive impact on safety climate and the supervisor-employee relationship. Similar findings are presented by Hambach and her colleagues (2011) in a study that focuses on the perceptions of chemical risks among blue-collar workers in large and medium-sized chemical companies in Belgium.

A final recurring theme in the literature referring to context that affects the relationship between risk communication and risk perception in complex interactive and tightly coupled organisations is the notion of trust (Conchie and Burns, 2008; Conchie and Burns, 2009; Hambach et al., 2011). Although the different authors use a subtly different approach, trust could be analysed at a person's level (i.e., the source of information) or at the level of information itself (i.e., the evaluation of trustworthy information). Quite often, the authors in this field of research refer to the integrative model of organisational trust (as presented by Mayer et al., 1995, and Schoorman et al., 2007), that defines trust as "… the willingness of a party to be vulnerable to the actions of another party based on the expectation that the other will perform a particular action important to the trustor, irrespective of the ability to monitor or control that other party" (Mayer et al., 1995, p. 712). The issue of 'the willingness to be vulnerable to the actions of another party' in this context refers to "the nature of the human actors that influence behavioural change" (Denyer et al., 2008, p. 397).

On the other hand, the notion of lack of trust is mentioned as well as a contextual factor that influences risk perceptions in general (Burns et al., 2006; Conchie and Burns, 2008) and the evaluation of the risk communicator in particular (Zacharatos et al., 2005; Hambach et al., 2011). Zacharatos and her colleagues (2005) indicate that lack of trust in management leads to job dissatisfaction and subsequent unsafe behaviour.

Focusing on the role of trust as a contextual surrounding factor, Burns et al. (2006) argue that two forms of trust are at play; implicit and explicit trust. Implicit trust is rooted in the basic underlying assumptions that are the essences of safety culture, while explicit trust is part of the surface levels of safety culture (Burns et al., 2006, p. 1147). In other words, implicit trust is about the non-tangible attributes of an organisation, such as values and beliefs, while explicit trust can be captured in figures and tables, such as the number of accidents or days absent. The way in which these implicit and explicit expressions of trust are communicated has an effect on the workers' trust beliefs (Conchie and Burns, 2008). The language used by management also has an impact on the workers' level of trust, and thus on their perception of a certain risk. Major incidents are quite often described by management as 'operator error', and in this way blame individuals (Harvey et al. 2002; Nævestad, 2008). In combination with information that is not user-friendly and difficult to understand for lower levels in the organisation (Beus et al., 2010; Hambach et al., 2011), this enforces the lack of trust in risk communication from higher hierarchical levels (Hambach et al., 2011).

3.1.3 Conclusions

Contextual factors that might influence the relationship between risk communication and risk perception can be categorised into:

- external and internal surrounding factors,
- the nature of the human actors,
- social systems.

Table 3-2 illustrates these three categories with findings from the literature concerning contextual factors.

Context
External and internal surrounding factors - Complex interactive and tightly coupled systems - The amount of trust among the organisational members
The nature of the human actors - Age, experience, language, rhetoric - Beliefs concerning level of perceived control and luck - Guilt, blame and power - Problem framing and problem domain familiarity
Social systems - Safety culture, social influence, cultural misunderstanding - Cultural processes

Table 3-2 Contextual factors divided into three categories

The next paragraph will explore the interventions that influence the relationship between risk communication and risk perception in complex interactive and tightly coupled organisations.

3.2 Interventions

3.2.1 Introduction

In the context of this systematic review, 'interventions' must be seen as the tools managers have at their disposal to influence the relationship between risk communication and risk perception in complex interactive and tightly coupled organisations. They can be on an operational level, such as the implementation of safety trainings and courses, and on a behavioural level, such as leadership style. According to Denyer et al. (2008, p. 397) it is important to examine not just the nature of the intervention, but its implementation as well. Therefore, interventions have to be considered in a wider context than only the use of specific tools or forms of communication such as letters, mails, or conversations.

Examining the literature that resulted from the systematic review process, only 11 out of 26 papers indicate interventions that might influence the relationship between risk communication and risk perception. From these 11 papers, nine

papers are based on empirical research. However, only four of them are focused on high-reliability organisations such as nuclear power plants (Harvey et al., 2001; Harvey et al., 2002), or chemical companies (Grote and Künzler, 2000; Hambach et al., 2011). Two out of the nine research papers (Sauer, 1996; Hambach et al., 2011) used a qualitative method involving seven focus groups each. The other seven research papers that offer insights on interventions are based on quantitative research methods.

In the next section I will discuss the literature and the findings of this review concerning the interventions that influence the relationship between risk communication and risk perception, and trigger specific mechanisms.

3.2.2 Review of the literature

The interventions that are found in the reviewed literature are presented in Table 3-3.

Interventions	References
The role of management and trade unions in safety culture	Grote and Künzler (2000); Specht et al. (2006); Kath et al. (2010)
Leadership style / Management style	Geller (2001); Harvey et al. (2001); Harvey et al. (2002); Michael et al. (2006); Nævestad (2008); Conchie and Burns (2009); Kath et al. (2010)
Hierarchical communication	Hambach et al. (2011)
Adding people to a decision process	Beus et al. (2010)
Introducing safety training and learning mechanisms	Grote and Künzler (2000); Harvey et al. (2001); Specht et al. (2006); Beus et al. (2010)
Creating comprehensible content of communication	Sauer (1996); Hambach et al. (2011)
Human Risk Management System	Specht et al. (2006)

Table 3-3 Interventions and their references

As mentioned in the previous chapter, Harvey and his colleagues argue that safety culture involves perceptions, attitudes and behaviours of individuals within an organisation (Harvey et al., 2002, p. 19). In that perspective behaviour intervenes in the relationship between risk communication and risk perception. As mentioned in the introduction chapter, communication is a process of establishing meaning (Scott and Marshall, 2005, p. 91), and process implicates

a series of actions or steps taken in order to achieve a particular objective. I would therefore like to make a distinction between communication interventions on the sender's and on the receiver 's level. On the sender's level these interventions are clustered around management style and leadership actions. Michael et al. (2006) found sound evidence for employees' higher perception of job satisfaction due to open and honest risk communication between leader and subordinate. Hambach and her colleagues also found a correlation between comprehensible risk communication and mutual respect between blue-collar workers and management (Hambach, 2011). Specht et al. (2006) also describe the role of leadership as a key intervention in the relationship between risk communication and risk perception. They denote the influence management might have in supporting people in their sharing of a safety culture. Specht et al. call this 'Human Risk Management System' and claim that it is based on communication and confidence empowerment, and is driven by organisations through information and training (Specht et al., 2006, p. 530). Grote and Künzler (2000) agree that communication and training have a pivotal role in the adjustment of risk perceptions, but on the sole condition that they are applied in an appropriate way (Grote and Künzler, 2000, p. 148). Risk perceptions among workers in hazardous environments have been developed over years, and a few communication actions such as once-in-a-year safety trainings, or top-down safety programme initiatives are not sufficient to produce significant changes in workers' risk-taking behaviours and safety attitudes (Harvey et al., 2001, p. 631). Blue-collar workers generally perceive these training programmes as a waste of time and effort, as their sole purpose is to meet the requirements imposed by general management. Harvey et al. (2001) conclude that training programmes only seem to have an effect on attitudes for the higher grades of employees. However, although Harvey and her colleagues extensively studied the effects of a safety-training programme among staff at a nuclear processing plant itself, the communication process that supported the training programme itself was not taken into account.

This leads to the second distinction: communication interventions on the receiver's level. The perceived attitudes of management, and the way they

communicate about and behave in respect to risk, have an impact on the employees' ability to develop collective rules of how to deal with risk in day-to-day operations (Specht et al., 2006, p. 533). Kath et al. (2010) offer a similar observation. They indicate that employees, who feel the freedom to communicate safety concerns with their supervisors, can have a direct effect on upward safety communication. This behaviour can only exist on the prerequisite that the organisation values the employee. The feeling of being valued is not only based on trust and individual perceptions, but also on good supervisor-employee relationships and attitudes (Naevestad, 2008; Kath et al., 2010, p. 648).

Michael et al. (2006) also indicate this pivotal role of communication qualities at higher management level, and the importance of a good leader-member exchange (LMX) in enhancing workplace safety. The LMX theory, developed by Graen and his colleagues (Graen and Scandura, 1987; Graen and Uhl-Bien, 1995), suggests that leaders tend to have different types of relations with different members of the same work group. The assumption is that high LMX relationships are beneficial for both leader and member, but also for the work group and even for the organisation (Phillips and Bedeian, 1994). In their study, Michael et al. (2006) found that the influence of LMX was greater than that of safety communication in predicting employee job satisfaction and safety-related issues. However, many scholars (such as Phillips and Bedeian, 1994; Brower et al., 2000; Becerra and Gupta, 2003; Uhl-Bien, 2006; Schoorman et al., 2007) suggest the critical role of frequent communication in creating trust in leader-member exchange. Therefore, the question could be raised whether the focus of the method Michael and her colleagues used to research the impact of safety communication was not too narrow? In the research methodology part of their paper, Michael and her colleagues disclose, "Safety communication was measured by using six items of the Hofmann and Stetzer (1998) safety communication scale" (Michael et al., 2006, p. 472). Unfortunately, every item in this scale refers specifically to safety communication and its relationship to the supervisor. I would argue that the role of leadership in safety-critical operations is more than merely talking about safety issues.

3.2.3 Conclusions

Table 3-4 illustrates the different interventions on the relationship between risk communication and risk perception in complex interactive and tightly coupled organisations.

Interventions
Leadership style - Adapted safety training and learning mechanisms - Hierarchical communication - Adding people to a decision process - Creating comprehensible content of communication - Human Risk Management System

Table 3-4 Interventions linked to leadership style

A remarkable observation concerning 'interventions' is that they all refer to leadership style and management actions. Apparently, when it comes to communication with the intention to have an impact on the relationship between risk communication and risk perception in complex interactive and tightly coupled organisations, the only plausible intervention is linked to a leadership capability. However, none of the selected papers in this systematic review explicitly disclose the kind of communication style these leaders should apply. Furthermore, a legitimate question that has to be raised is what kind of leadership do these organisations require?

This link between risk communication and leadership, and the specific kind of leadership complex interactive and tightly coupled organisations call for, will be further discussed in the penultimate chapter of this part of the thesis (see Part II: "4.2 Discussion" on pages 159-161).

In the next chapter I will explore the mechanisms that might be triggered by the interventions, as mentioned earlier in this chapter.

3.3 Mechanisms

3.3.1 Introduction

In this systematic review a mechanism must be interpreted as a phenomenon which, in the context of the relationship between risk communication and risk perception in complex interactive and tightly coupled organisations, is triggered by certain interventions. Safety awareness, for example, is a mechanism that in the context of having a certain age and experience in the organisation can be triggered by the intervention of implementing training and learning sessions. A mechanism is thus a kind of effect from an intervention in a certain context, “offering the potential of long-term benefits to the employees and/or to their organisation” (Denyer et al., 2008, p. 397).

The literature that resulted from the systematic review process offered seven papers (out of 26) that indicate mechanisms that are triggered by some interventions in the relationship between risk communication and risk perception. From these seven papers, five are based on empirical research. However, three research papers are based on empirical research in organisations with complex interactive and tightly coupled systems, such as nuclear power plants (Harvey et al., 2001), NASA (Dillon and Tinsley, 2008), and the petrochemical industry (Grote and Künzler, 2000). One exception is the work by Dillon and Tinsley (2008), as they mixed different sources of data in their research. Dillon and Tinsley (2008) researched the framing of near-misses on organisational learning, based on quantitative surveys among students (MBA students and undergraduates) and NASA managers. All of the five research papers that offer insights on ‘mechanisms’ are based on quantitative research methods.

In the next section I will discuss the literature and the findings of this review concerning mechanisms that are triggered by some interventions in the relationship between risk communication and risk perception in complex interactive and tightly coupled organisations.

3.3.2 Review of the literature

The mechanisms that are found in the reviewed literature are presented in Table 3-5.

Mechanisms	References
Communicating and collaborating for safety through team working	Specht et al. (2006)
Individuals' information-processing biases affect risk perception and decision making	Houghton et al. (2000); Harvey et al. (2001); Dillon and Tinsley (2008)
Workers are operating collectively, developing collective rules of dealing with risk	Specht et al (2006)
Awareness, sensemaking, mindfulness	Specht et al. (2006); Nævestad (2008); Nævestad (2009)
Different cultural values imply different psychological contracts in relation to safety attitudes and behaviour	Harvey et al (2001)
Safety trainings may be have seen as a "top-down" initiative	Harvey et al. (2001)
Feelings of complacency and hubris	Grote and Künzler (2000); Dillon and Tinsley (2008)

Table 3-5 Mechanisms and their references

According to Denyer and his colleagues, a logical prescription in terms of if you want to achieve outcome *O* in context *C*, then use intervention type *I*, raises the issue of causality (Denyer et al., 2008, p. 395, citing Pawson and Tilley, 1997). This issue of causality can be answered "by asking through which generative mechanism(s) the intervention produces the outcome in the given context" (Denyer et al., 2008, p. 395). As we saw in the previous chapter, all interventions that intervene in the relationship between risk communication and risk perception in complex interactive and tightly coupled organisations are rooted in leadership actions. The generative mechanisms are hence linked to how these leadership actions are interpreted and processed.

A helpful insight into that phenomenon is offered by Dillon and Tinsley (2008). They argue that individuals have two general information-processing systems: an associative one and a rule-based one (Dillon and Tinsley, 2008, p. 1437). The associative system is based on emotions, feelings and interpretations, while the rule-based system operates according to formal rules of reasoning and evidence. Dillon and Tinsley claim "perceived risk is the product of the

associative system processing […] that influences behaviour" (Dillon and Tinsley, 2008, p. 1437). Interestingly, Dillon and Tinsley's empirical research was focused on NASA employees, of whom might be presumed that they are trained to deal with risks based on a cognitive evaluation of evidence and calculated risk statistics, and not on emotions and feelings.

If we link the findings of the literature on mechanisms, as presented in Table 3-5, to both information-processing systems, we can create two distinct groups (see Table 3-6).

Mechanisms
Associative information-processing system - Awareness - Sensemaking - Mindfulness - Psychological contracts - Feelings of complacency and hubris
Rule-based information-processing system - Team working - Developing collective rules of dealing with risk - Scepticism through safety trainings

Table 3-6 Mechanisms linked to information-processing systems

3.3.3 Associative systems

Mechanisms, such as awareness, sensemaking, and mindfulness are all based on emotions, feelings and interpretations, which are the key qualifications of the associative information-processing system. In two separate research programmes that focus on the role and dynamics of risk awareness in relation to safe behaviour, Specht et al. (2006) found sound evidence that the use of communication in a training programme increases the level of risk awareness among the participants. However, Harvey et al. (2001, p. 628) argue that cultural differences might imply different psychological contracts in relation to safety attitudes. These 'psychological contracts' refer to frames of reference (Nævestad, 2008) organisational members adhere. Making organisational members aware of these frames of reference by aligning them is closely linked to the idea of mindfulness, which is the basis of the high-reliability theory. Weick and Sutcliffe define mindfulness as 'a rich awareness of discriminatory detail.

[…] This is sometimes called situation awareness' (Weick and Sutcliffe, 2007, p. 32). In other words, mindfulness is about awareness and attention, having the 'big picture' in which details differ. A remark could be raised whether the principles of mindfulness may be hard to translate into action (Nævestad, 2009) because they are rooted in the associative information-processing system, which is based on emotions, feelings and interpretations (Dillon and Tinsley, 2008). Therefore, safety trainings might not be the only solution to teach organisational members to become more aware or mindful. Communication in the sense of disclosing and disseminating information on the current 'health' of the system, including anomalies, errors, mistakes and incidents (Denyer et al., 2008, p. 401) might 'correct' the associative system.

In that sense, the concept of sensemaking might offer a valuable ad-on. The basic idea of sensemaking is that 'reality is an ongoing accomplishment, which is derived from efforts to create order and make retrospective sense of what occurs' (Weick, 1993, p. 635). In other words, sensemaking is a process of scanning the environment for valuable clues to make a retrospective interpretation of what happens. According to Nævestad (2008) we do this by employing frames of reference to make sense of the world. Those frames of reference 'represent a way of focusing our attention as we are cognitively unable to interpret and examine everything' (Nævestad, 2008, p. 158). Hence, when the information is too complex, the associative information-processing system takes it over from the rule-based system[6].

A final reference to the associative information-processing system is the phenomenon of complacency and hubris. Research by Grote and Künzler (2000) indicates a deficiency between results from a formal safety audit and the communicative validation of a deeper understanding of a safety culture in a company. They conclude that safety survey results are in fact indicators of more or less shared views of safety management, but not indicators of more or less safe behaviours and attitudes (Grote and Künzler, 2000, p. 147). In other words,

[6] This notion of associative information-processing system is based on Kahneman's concept of System 1 and System 2 thinking (Kahneman, 2011)

successful safety evaluations can bias the risk perception of the organisational members, and lead to an attitude lacking self-criticism (Grote and Künzler, 2000, p. 148) and feelings of complacency. Dillon and Tinsley (2008) support this claim by indicating how near-misses are perceived as successes, and how this information leads people to choose a riskier alternative because of a lower perceived risk following near-miss events (Dillon and Tinsley, 2008, p. 1437).

3.3.4 Rule-based systems

Rule-based information-processing systems operate according to formal rules of reasoning and evidence (Dillon and Tinsley, 2008, p. 1437). In a risk context, workers operate collectively and develop collective rules (Specht et al., 2006, p. 533). Research by Specht et al. (2006) indicates that several processes such as informal negotiations, imitation and communication spur the development of these rules. Furthermore, these collective rules are most often based on existing cultural norms and team values.

Another finding in this study by Specht et al. (2006) that can be linked to rule-based information-processing systems is that risk communication might reinforce a communicative attitude among team members that eventually will lead to more safety through team working. A team of operators, which was supported by the management and had the trust of colleagues, demonstrated high collaboration and communication within the team. This allowed them to successfully resolve safety issues and thus contribute to the safety culture development in the workplace (Specht et al., 2006, p. 536).

This communicating and collaborating, based on formal rules of reasoning and evidence, might lead to sceptical questioning of those rules as well. In an evaluation of the effectiveness of safety trainings in the nuclear industry, Harvey et al. (2001) found that safety programmes initiated by management are often perceived as a ‘top-down’ initiatives, and ‘thus are less likely to result in improved attitudes, particularly in relation to communications and personal responsibility’ (Harvey et al., 2001, p. 629). The lack of empowerment leads to the loss of agreement about the goals of the training. This questioning of goals

and formal rules in the organisation are also traits of a rule-based information-processing system.

3.3.5 Conclusions

This chapter examined the mechanisms which in the context of the relationship between risk communication and risk perception in complex interactive and tightly coupled organisations are triggered by the interventions. The literature offers two sets of generative mechanisms that are linked to the previously mentioned interventions (leadership actions) as to how these leadership actions are interpreted and processed. These mechanisms are an associative and a rule-based information-processing system.

The next chapter will focus on the outcome of the interventions in the context of risk communication and risk perception in complex interactive and tightly coupled organisations.

3.4 Outcome

3.4.1 Introduction

Outcome is the result of an intervention in its various aspects (Denyer et al., 2008, p. 397). In this systematic review, 'outcome' can be a reduced or adjusted risk perception, a higher involvement in safety, as well as a lower accident rate among the employees. In other words, not all of the interventions that have an impact on the relationship between risk communication and risk perception in complex interactive and tightly coupled organisations automatically have an effect on either risk perception or risk communication.

Examining the literature that resulted from the systematic review process, only five out of 26 papers indicate outcomes as results of interventions in the relationship between risk communication and risk perception. From these five papers, four papers are based on empirical research. However, only one is focused on organisations with complex interactive and tightly coupled systems;

i.e., a UK gas plant (Conchie and Donald, 2006). All of the research papers that offer insights on 'outcomes' are based on quantitative research methods.

In the next section I will discuss the literature and the findings of this review concerning outcome as a result of certain interventions in the relationship between risk communication and risk perception.

3.4.2 Review of the literature

The different 'outcomes' that are found in the reviewed literature are presented in Table 3-7.

Outcome	References
Reduced risk perception and involvement in safety	Sitkin & Weingart (1995); Conchie & Donald (2006)
Mutual respect	Specht et al. (2006)
Employee's safety involvement	Specht et al. (2006)
Lower accident rate due to adjustment of risk perception	Houghton et al. (2000); Conchie & Donald (2006)
Reduced risk perception	Conchie & Donald (2006)
'Risky shift phenomena'	Houghton et al. (2000)
Functional distrust, mindful organisation	Conchie & Donald (2006); Nævestad (2008)

Table 3-7 Outcomes and their references

An overall observation is that the results of the interventions in their various aspects can be divided into two categories: outcomes on an individual level, and outcomes on an organisational level. This is illustrated in Table 3-8.

Outcome
Individual - Risky shift phenomena - Reduced risk perception - Employee's safety involvement
Organisational - Functional distrust - Mutual respect

Table 3-8 Outcome linked to individual and organisational level

3.4.3 Outcome on individual level

Sound leadership (*Intervention*) that involves people at all levels in a safety decision process (Beus et al., 2010) triggers (*Mechanism*) different

psychological contracts in relation to safety attitudes and behaviour (Harvey et al., 2001) that will lead to (*Outcome*) an employee's higher safety involvement (Specht et al., 2006). Conchie and Donald, studying the attitudes of trust among UK offshore gas workers, confirm that open and trustworthy communication reduces individual risk perception (Conchie and Donald, 2006, p. 1151-1152). In this study as well, the authors emphasise good leadership (*Intervention*) that 'promotes shared values and commitment to an organization's safety policies' (Conchie and Donald, 2006, p. 1152), which is the basis for a safety culture (*Context*).

Houghton and her colleagues studied the impact of cognitive biases on the risk perception process (Houghton et al., 2000). Although this study does not deal specifically with complex interactive and tightly coupled organisations, it uncovers that some biases, such as the illusion of control, decrease risk perceptions in a decision making process. This may lead to a so-called 'risky shift phenomena' (Houghton et al., 2000, p. 326); which is a situation where due to group discussions, individuals may agree to take more risks than *a priori*, and not to less extreme, moderate, or even risk aversive positions. Furthermore, Houghton et al. confirmed that risk perception is importantly related to risky choices at both the individual and the team level, as are cognitive biases (Houghton et al., 2000, p. 342).

3.4.4 Outcome on organisational level

Another outcome that emerges in the literature referring to outcome of the relationship between risk communication and risk perception in complex interactive and tightly coupled organisations is the role of functional distrust in a way it can help to ensure a safe work environment (Conchie and Donald, 2006). Functional distrust can be described as an integral part of a mindful organisation, as mindfulness is about awareness and attention, having the 'big picture' in which details differ (Weick and Sutcliffe, 2007). Such an attitude requires a 'healthy form' of distrust that allows organisational members to check each other's possible unsafe handlings. Conchie and Donald's analysis

revealed attitudes of distrust as better predictors of safety performance compared to attitudes of trust (Conchie and Donald, 2006, p. 1158).

However, as mentioned in ‘3.1 Contextual factors’, trust among organisational members is perceived as a beneficial context for the relationship between risk communication and risk perception. The impact of communication on trust, and the subsequent impact on reduced or adjusted risk perception, is examined in depth by many scholars (see for example: Houghton et al., 2000; Burns et al., 2006; Conchie and Donald, 2006; Conchie and Burns, 2008). Furthermore, we know that communication is one of the key components in creating trust (Zacharatos et al., 2005; Hambach et al., 2011). Therefore, speaking the same language refers to a shared and trusted social structure, which results in mutual respect (Specht et al., 2006, p. 535).

In the next chapters, I will synthesise the different findings concerning the relationship between risk communication and risk perception in complex interactive and tightly coupled organisations, indicate its limitations, and offer recommendations for further research.

4 DISCUSSION

4.1 Introduction

This systematic review started by raising the question about the relationship between risk communication and risk perception in complex interactive and tightly coupled organisations. From both a researcher's and a practitioner's point of view I was anxious to know what the literature offers on this particular topic. As a consultant in the field of risk and crisis communication, I often meet managers in high hazardous organisations struggling to find the right 'tone of voice' to connect with their subordinate's perception concerning the risk issue at hand, in order to make their workplace, the environment, and the entire industry much safer. From a researcher's point of view I was keen to disclose the underlying mechanisms that intervene on this relationship between communication and perception. This double objective, a practical and an empirical one, was my driving force to embark on this DBA programme. It also explains why I aimed to combine knowledge with practice in this particular research project. The reason why I applied the so-called 'CIMO-logic' (Denyer et al., 2008) has to be seen in the light of this aim, as this logic is an attempt to synthesise previously published research in the form of more solution-oriented or prescriptive knowledge. The rationale for this CIMO-logic is the intention 'to add to analysis and explanation, specifications for interventions to transform present practices and improve the effectiveness of organizations' (Denyer et al., 2008, p. 393-394).

Looking at the literature on the relationship between risk communication and risk perception in complex interactive and tightly coupled organisations, the findings as presented in accordance with the CIMO-logic look quite fragmented (see Table 4-1). We cannot follow the simple reasoning that in order to achieve a specific outcome, we have to do one intervention in a given setting. According to Denyer and his colleagues we have to include 'a combination of interventions (I^1 … I^n) that invoke particular generative mechanisms (M^1 … M^n) to produce a particular outcome (O) in a specific context (C)' (Denyer et al., 2008, p. 407).

Context	Interventions	Mechanisms	Outcome
External and internal surrounding factors - Complex interactive and tightly coupled systems - The amount of trust among the organisational members **The nature of the human actors** - Age, experience, language, rhetoric - Beliefs concerning level of perceived control and luck - Guilt, blame and power - Problem framing and problem domain familiarity **Social systems** - Safety culture, social influence, cultural misunderstanding - Cultural processes	**Leadership style** - Adapted safety training and learning mechanisms - Hierarchical communication - Adding people to a decision process - Creating comprehensible content of communication - Human Risk Management System	**Associative information-processing system** - Awareness - Sensemaking - Mindfulness - Psychological contracts - Feelings of complacency and hubris **Rule-based information-processing system** - Team working - Developing collective rules of dealing with risk - Scepticism through safety trainings	**Individual** - Risky shift phenomena - Reduced risk perception - Employee's safety involvement **Organisational** - Functional distrust - Mutual respect

Table 4-1 Overview of the findings presented in the CIMO-logic

4.2 Discussion

Going back to the practical problem behind the research question, about how managers have to communicate with their subordinates to have an impact on their risk perceptions, multiple interventions can be applied. These interventions, as revealed by systematically reviewing the literature are:

I[1] Put safety trainings and learning systems in place, adapt them to the different levels in the organisation (based on knowledge, experience, etc.), champion these trainings, and make sure these actions are not perceived as a ‘top-down’ initiative for the benefit of management to get high scores on safety audits,

I^2 Install a hierarchical communication, based on comprehensible content that resonates with the employees' problem domain familiarity and their beliefs concerning the perceived levels of control or luck,

I^3 Add people to the decision process. This requires a 'no blame, no shame' context where organisational members are respected and valued for their expertise and problem domain familiarity,

I^4 Introduce a 'Human Risk Management System' as it reveals the role social processes play when risks have to be communicated. The context in which employees in complex interactive and tightly coupled organisations find themselves and how they perceive certain risks, differ substantially from risk perceptions among members of the general population.

A remarkable observation concerning 'interventions' is that they all refer to leadership style and management actions. Apparently, when it comes to communication with the intention to have an impact on the relationship between risk communication and risk perception in complex interactive and tightly coupled organisations, the only plausible interventions are linked to the leadership capabilities. Unfortunately, none of the selected papers in this systematic review explicitly disclose what kind of leadership is required in these interventions. Conchie and Donald suggest 'transformational leadership' as 'Transformational leaders engage in actions that promote trust from workers, which workers reciprocate by increasing their commitment to goals set out by the leader' (Conchie and Donald, 2006, p. 1153, citing Dirks and Ferrin, 2002). However, their research was focused on the role of trust and distrust attitudes toward workmates, supervisors, offshore managers, and contractor staff (Conchie and Donald, 2006, p. 1154), and did not examine the type of leadership that is required to maximise trust in the leader. Only Michael et al. (2006) explicitly mentioned LMX as an intervention that enhances workplace safety. But the question could be raised if Leader-Member Exchange is the most appropriate form, as it is based on dyadic relationships in which leaders tend to have different types of relations with different members of the same

work group (see for instance: Graen and Scandura, 1987; Phillips and Bedeian, 1994; Graen and Uhl-Bien, 1995; Uhl-Bien, 2006).

It is worth notifying that the different interventions that emerged from the literature in this systematic review are well in line with the basic principles of the High-Reliability Theory and its concept of creating a 'mindful organisation' (Weick and Sutcliffe, 2007). Three of the earlier described interventions (Safety trainings and learning mechanisms, adding people to the decision process, and creating comprehensible content of communication) refer to the basic principles of HRO.

Regarding the 'mechanisms' triggered by particular communicative 'interventions', Dillon and Tinsley (2008) claim that organisations fail to learn from near-misses as they perceive these events as successful risk-taking. Dillon and Tinsley argue that individuals' risk perception is rooted in two general information-processing systems: an associative one and a rule-based one (Dillon and Tinsley, 2008). The latter operates according to formal rules of reasoning and evidence, while the former is based on emotions and interpretations. These two systems influence individuals' decision-making processes and safety behaviour, but the associative system processes often prevail over rule-based system processes (Dillon and Tinsley, 2008, p. 1437). In other words, people tend to process information based on emotions rather than relying on reason and evidence-based information. As a consequence, "people with near-miss information make riskier choices than those without this information, because the near-miss events lead them to perceive a lower level of risk regarding the decision situation" (Dillon and Tinsley, 2008, p. 1438).

5 LIMITATIONS AND FURTHER RESEARCH

5.1 Limitations

It might be possible that other domains of the literature examined the relationship between risk communication and risk perception in a more balanced way. One example that was excluded from the systematic review, as it did not meet the inclusion criteria, was a theoretical paper by Vogus and his colleagues (2010). In this essay, they present an integrative framework of how patient safety is produced and sustained through safety culture. This framework is based on enabling, enacting and elaborating a safety culture, where “every step is rooted in mindful action and sensemaking” (Vogus et al., 2010, p. 70). It could be worthwhile to review the literature on the relationship between risk communication and risk perception in other, non-complex interactive and tightly coupled organisations, and by doing so examine their similarities and differences.

The literature on how risk communication is executed in complex interactive and tightly coupled organisations can roughly be broken down into two categories: face-to-face (e.g., personal interaction, team meetings, town hall meeting, etc.) and by means of mediated communication (e.g., telecommunications, internet, e-mail, etc.). However, I could not find one piece of empirical research concerning the impact of social media (such as Facebook, Hyves, Twitter, etc.) on risk perception and risk communication among organisational members.

And finally, it might be argued in hindsight that using the CIMO-logic was probably not the most optimal option for examining the literature. Although this CIMO-logic provided me with the structure to organise the literature, it is a very linear focused way of achieving defined answers to an organisational question. Therefore, it might not be the most suitable logic to examine the literature that refers to communication, as this field of social science is characterised as not linear, nor predictable, but more as emotional processes (Shotter, 1997; Damasio, 2006; Dillon and Tinsley, 2008; Shockley-Zalabak, 2009; Marynissen,

2011). In that perspective, it might be argued that the “outcome” is not only dependent on the interventions and subsequent mechanisms, but on many more dependent and independent variables such as power, politics, hidden agendas, and the like. Furthermore, in the CIMO-logic the context is defined as “the surrounding (external and internal environment) factors and the nature of the human actors that influence behavioural change” (Denyer et al., 2008; p. 397). However, it might be argued, “context is not independent of human agency, and [therefore it] cannot be objectively assessed in a scientific form” (Grint, 2005; p. 1471).

5.2 Recommendations for further research

By systematically reviewing the literature on the relationship between risk communication and risk perception in complex interactive and tightly coupled organisations, it becomes apparent that this specific domain of research has been neglected over the last two decades. Nevertheless, from a practitioner’s point of view, the need for more insights in this field is of utmost importance. Strict national and international safety regulations, severe pressure from environmental interest groups, and precautionary attitudes from investors and shareholders (Breakwell, 2007) force complex interactive and tightly coupled organisations to steer their communication from a different intervention-approach.

Although the literature offers ample insights of how to communicate risks with civilians, almost none of these findings are used when it comes to communicate risk in complex interactive and tightly coupled organisations. Theories such as affect heuristics (Slovic et al., 2002), the democratic view on risk communication (Gurabardhi and Gutteling, 2002), social amplification of risk (Kasperson et al., 1988), or the psychometric model (Slovic, 2000) are neglected when it comes to empirically researching the effects of risk communication on risk perception in these specific type of hazardous organisations. Therefore, this offers multiple options for further research.

As this systematic review revealed, multiple leadership actions must be seen as the key interventions that evoke particular generative mechanisms, which produce a particular outcome in a specific context. However, the systematic review did not disclose what kind of leadership style is the most appropriate one for communicating risk in complex interactive and tightly coupled organisations[7]. Therefore it is recommended to empirically research different leadership interventions in relation to risk communication in these types of complex interactive and tightly coupled organisations, while taking into account the CIMO-logic and the dynamics between the different combinations (Denyer et al., 2008, p. 407). In other words, the context and outcome as indicated in this systematic review are determined, but the different interventions and mechanisms are the subject for further exploration.

On the other hand, this systematic review also suggests how individuals perceive and interpret risk messages according to their information-processing system. Still, this conclusion was based on research that explored how both NASA employees and survey respondents interpret messages about near misses, and its impact on decision-making under risk (Dillon and Tinsley, 2008).

5.3 Towards an empirical research project

From an interpretivist point of view, I was not expecting to receive a clear-cut answer from the literature on how to communicate risks to have an impact on employees' risk perceptions and risk aversive attitudes. However, I was surprised about the ease with which various authors use the word 'communication' in the context of transferring information from point A to point B. None of the reviewed papers made a critical reflection on the interactive cognitive and social processes that might influence the interpretation of the received information (Rochlin, 1999). This might indicate that my assumption about how risk communication should work - namely not simply as an

[7] In a paper exploring safety leadership, Clarke (2013) indicates how active transactional leadership is important in ensuring compliance with rules and regulations, whereas transformational leadership is primarily associated with encouraging employee participation in safety. However, this paper was published two years after I submitted this systematic review of the literature.

information tool but as a means to create risk aversive perceptions - is wrong. On the other hand, it might suggest that all the reviewed literature simply takes for granted that transferring information is the most optimal way to adjust employees' risk perceptions that ultimately will lead to safe behaviour. In an attempt to question this assumption and to acquire more insights on the effects of communication in these types of organisations, I undertook an empirical research project that focused on individual risk perceptions. This will be described in Part III of this doctoral thesis.

PART III: PROJECT 2 – EMPIRICAL RESEARCH

ABSTRACT

Communication is often recognised as pivotal for organisations managing high-risk technologies. Such communication is generally informed by industry and government regulations, which are then translated into procedures, guidelines, and the like. These are disseminated, discussed and instructed to the staff by executive team members, with the aim of reducing potential dangers. However, it is questionable as to whether all organisational members share the same perception, and therefore interpretation, of risk. Interview data evidence suggests that employees, other than the executive team, are not preoccupied with regulations, but rather with the question of how to keep themselves and their fellow workers safe. Based on this assumption, mere communication is perceived to be inadequate to create common awareness concerning safety and potential risks.

This part of the doctoral thesis offers the results of empirical research, based on repertory grid, conducted with all employees of a natural gas terminal in Belgium about their perceptions of the risks faced by their organisation. It reveals that the people occupying different roles in the organisation do indeed have very different perceptions of workplace risks. These differences are affected by various factors such as the level of experience and tacit knowledge. However, previous real life threatening experiences seem to be a dominant predictor for a broader and more divergent view on the present risks. These findings might have a major impact on risk communication, safety courses, and trainings.

1 INTRODUCTION

Safety culture is a major issue in organisations that face a constant threat of risks linked to their business (Grote and Künzler, 2000; Marynissen and Ladkin, 2012). A sound safety climate, in which all employees are aware of the potential risks and dangers, might prevent businesses from the perils of potential disasters. But how to create an environment where the focus for safety is not solely based on procedures or hollow rhetoric from board members, but on responsible and risk-avoidance behaviour from all staff? What is the magic formula for a corporate culture that focuses on the avoidance of accidents?

The following situation illustrates this discrepancy between intentions and behaviour quite well, between what is said about safety and what is executed. In an official brochure of an international gas production company, under the paragraph *Corporate Governance* it says that this company "will represent best practice in health, safety and the environment" (Gassco, 2011; p. 18). And in the foreword the President and CEO of that company clearly state that they "will not compromise on safety" (Gassco, 2011; p. 3). In this very same company, during a safety training, one of the operation supervisors was asked what he should do in case of a major gas leak in the receiving terminal on a Saturday night, when he and his colleague were the only two operators present in the control room. The man responded promptly: "I will call my boss. I'm sure he will solve it." Giving him the scenario that his boss was not accessible by phone as he was on the plane to a holiday destination, the supervisor rubbed his chin, reflected for a couple of seconds, and finally answered: "Well … I honestly wouldn't know!" This operation supervisor is not a fresh, inexperienced employee. He has a bachelor degree in mathematics and has been with this company for more than ten years.

There is no doubt that safety is a top priority in this company. This can be illustrated by the President and CEO's annual statements about the topic, the multiple safety trainings that every employee has to follow on a regular basis (minimum twice a year), the numerous safety procedures that are disseminated

among all staff, and the millions of Euros that are invested in safety infrastructure and the improvement of a safer environment on a yearly basis. However, the question could be raised why after all these efforts and millions of Euros of investment, this operation supervisor still seems to be unaware of how to handle the risks of the business he is working in. This example indicates that he has not thought seriously about what he would do in the event of an emergency, despite all of the existing procedures and trainings.

Now, it can be argued that this operation supervisor, as well as the majority of his colleagues, have a good brain and substantial work experience in the company. The safety trainings in this company, and the safety documents it disseminates among staff, are based on proven quality criteria (such as ISO-certificates, DVK-accreditations, etc.). If it is not the individual, nor the company who are to blame for this lack of responsible behaviour towards safety, the hypothesis could be that a safety culture's secret recipe must be found in the way in which safety information is presented and disseminated. This brings us to the issue of communication. In the traditional view of communication (Shockley-Zalabak, 2009) roughly speaking there are two parties, a sender and a receiver, a message, and one or more channels through which that message will be transferred. In this case, the message is about potential risks and how to avoid them. The channels are the safety trainings, the written procedures, and the CEO's message about presenting the best practices in safety. The primal senders in this communicative process are the President, the CEO, and the entire executive team. They set out the safety standards that are linked to the company's mission, vision and values. And besides the production controller, the receiver is every single employee in this company who deals with risk issues and safety. As argued before, the controller has all the required intellectual capabilities to execute his job, and communication professionals help the executive members of the company to produce the messages about risk and safety. It might be argued that these messages are not of poor quality. Despite all the efforts, we cannot speak of a sound safety culture in this company.

Therefore, another hypothesis could be raised; that different people in one organisation perceive the same type of risk differently. If that is the case, it means that each organisational member interprets the same piece of information in a different way, and consequently bases his or her actions on a personal interpretation of that information. In other words, it might be possible that although a very specific risk is well communicated and disseminated among staff, each of the staff members interpret it in a distinct way. If that is the case, it would be worthwhile to know what precisely affects this perception. This might be experience, education, age, or other factors. Following this rationale, the issue at hand does not have so much to do with the message itself, but more with the way a message is interpreted.

To gain a deeper insight into this, two research questions will be raised:

1. How do people within an organisation perceive the same type of risks?
2. What factors affect the perception of these risks?

These two questions derive from the previous systematic review of the literature (see Part II of this thesis) and will be empirically researched in an organisation that manages tightly coupled and complex interactive systems.

2 TOWARDS A RESEARCH QUESTION

In an attempt to gain a deeper understanding of the relationship between risk communication and risk perception in the domain of organisations managing complex interactive and tightly coupled systems, the existing literature on this topic was systematically reviewed in the previous research project (see Part II of this thesis). The rationale behind this systematic review was that by examining the literature on risk communication and risk perception in these very specific types of organisations, recommendations could be made to improve practices in risk communication that will ultimately lead to a better safety culture. In the following paragraphs I will explain how risk perceptions might have an impact on safety attitudes. In doing so, I will elaborate further on some findings of the systematic literature review. And finally, I will present the research questions derived from these findings which will form the basis for further examination in this part of the doctoral thesis.

2.1 Information processing systems

A finding that emerged from the systematic review of the literature on the relationship between risk communication and risk perception in complex interactive and tightly coupled organisations comes from Dillon and Tinsley (2008). They found that organisations and managers fail to learn from near-misses as they perceive these events as successful risk-taking. Dillon and Tinsley argue that individuals' risk perception is rooted in two general information-processing systems: an associative one and a rule-based one (Dillon and Tinsley, 2008). The latter operates according to formal rules of reasoning and evidence, while the associative system is based on emotions and interpretations. These two systems influence individuals' decision-making processes and safety behaviour, but the associative system processes often prevail over rule-based system processes (Dillon and Tinsley, 2008). In other words, people tend to process information based on emotions rather than relying on reason or evidence-based information. As a consequence, "people with near-miss information make riskier choices than those without this

information, because the near-miss events lead them to perceive a lower level of risk regarding the decision situation" (Dillon and Tinsley, 2008; p. 1438). As a result, they will show less safety behavioural attitudes.

Dillon and Tinsley based their research on previous work by Nobel laureate Daniel Kahneman and his late colleague Amos Tversky. In their seminal paper on Prospect Theory, Tversky and Kahneman (1974) suggest how a situation, once it is framed will determine individual risk behaviour. This happens as intuitive thinking uses simplifying shortcuts that will lead to biases and heuristics when it comes to making decisions in uncertain conditions. Heuristic may be seen as "a simple procedure that helps find adequate, though often imperfect, answers to difficult questions" (Kahneman, 2011; p. 98). People tend to make judgements of probability all the time. However, this is an almost impossible job, especially without knowing what exactly probability is. Thus, instead of judging the probability, most people actually judge something else that is easier to assess, but that will lead to systematic and predictable errors. When emotions are involved in this judging process, we call it an "affect heuristic". Paul Slovic (2002) found that people determine their beliefs about risks based on their likes and dislikes. Once confronted with a risk, emotions will automatically evaluate the feelings regarding that risk based on the experiences with that particular of similar risks. Perceptions of risk are thus based on emotions, and consequently on judgements (Finucane et al., 2000), because "emotion is a quicker, easier and more efficient way to navigate in a complex, uncertain and sometimes dangerous world" (Slovic, 2000; p. xxxi). One's emotional attitude towards things such as nuclear power, chemical hazards, or air pollution, drives a person's beliefs about their risks and benefits. In other words, if a person dislikes chemical hazards, she or he most probably believes that its risks are high and its benefits negligible (Kahneman, 2011). The understanding of how affect influences risk perception and behaviour is called one of the ten most important accomplishments in risk analysis over the last 30 years (Greenberg et al., 2012). Even though, it was never demonstrated among employees in organisations managing high-risk technologies.

Based on the principles of Prospect Theory, Kahneman (2011) elaborates on this topic in more recent work, by indicating two systems that drive the way we think, make choices, but also jump on errors. The first one, simply called "System 1 thinking", is what Dillon and Tinsley (2008) indicate as associative information processing. Kahneman's notion of "System 2 thinking" is the equivalent of Dillon and Tinsley's rule-based information processing. The main function of System 1 is "to maintain and update a model of our personal world" (Kahneman, 2011; p. 71). Through associations we link bits of information that are in line with, or confirm, our mental models. This is a very fast and effortless process in the brain that is predominantly triggered by language (for more details see: Bechara and Damasio, 2005). The downside of this process is that System 1 has no self-controlling system, and thus often makes mistakes. Now if we link this to communication, and risk communication in particular, we have internal norms for a vast number of categories (Kahneman, 2011; p. 71). When the received information is not in line with these individual norms, we immediately reject that particular piece of information or we redirect it to make it fit into an existing norm. If this information is linked to a specific emotion, System 1 will immediately like or dislike the information, places it on an imaginary risk scale, and will jump to conclusions. This explains why so many people dread the risk of a nuclear power plant, while neglecting the risk of a deadly accident at home.

System 2 has a controlling function. It restrains System 1 from making too many mistakes or wrong interpretations. We commonly call this cognitive reasoning. However, System 2 works at a much slower pace and demands lots of energy (especially glucoses and oxygen, for more details see: Lehrer, 2009). That is why wrong interpretations or false conclusions, as produced in System 1, are often not corrected by System 2. Dillon and Tinsley's study indicates that in organisations dealing with risks, the associative information processing system (or System 1) prevails over the rule-based information processing system (or System 2) when it comes to evaluating potential risks. Their assumption is that "perceived risk is the product of the associative system processing […] that influences behaviour" (Dillon and Tinsley, 2008; p. 1437).

The question could be raised whether Dillon and Tinsley's hypothesis is valid and applicable to all employees in every complex interactive and tightly coupled organisation, as their findings were based on quasi-experimental research with students and NASA employees. In an attempt to get more clarification on this issue, I will next elaborate on existing findings concerning how individuals perceive and act on information in general, and how they perceive risks in particular.

2.2 Perception of risk

Over the last decades, various scholars indicated how individuals perceive and interpret information in different ways. Weick's theory of sensemaking (Weick, 1979, 1993, 2001, 2005) is probably the most cited in this context. According to Weick, sensemaking is "a sprawling collection of ongoing interpretive actions" (Weick, 2005; p. 395). Weick refers to both a process of interpretation and a process of taking action. The interpretation part refers to how "individuals attempt to create order and make retrospective sense of the situations in which they find themselves" (Morgan et al., 1983, cited by Weick, 2005; p. 395). While the action part refers to individuals who are "creating and sustaining images of a wider reality, in part to rationalize what they are doing" (Morgan et al., 1983, cited by Weick, 2005; p. 395). These notions of interpretation and action are also described by Donnellon and her colleagues in the phenomenon of 'equifinal meanings' (Donnellon et al., 1986). Their research indicates that, although organisational members collectively act in the same way, each of them has a different understanding of the conveyed information. These different interpretations of a single message indicate a divide between the dissemination of information and the individual perception of that particular information.

Although this concept of equifinal meanings is based partly on Weick's theory of sensemaking, it differs on the level of taking action. While Weick (2005) indicates a process in which individual action is taken based on retrospective sensemaking, Donnellon et al. (1986) emphasise individual sensemaking which results in collective action and similar behavioural implications. Weick and

Donnelon's notion of interpretation of information is referring to 'interpretation in action', while the focus of this research is on 'interpretation out of action'. I therefore prefer to refer to Julian Orr's work on individual 'out of action perceptions' as he described in his ethnographic analysis of photocopier repair technicians (Orr, 1996). Although it was not Orr's primal intention to study interpretations and perceptions of given messages on an individual level, he observed how repair people received official messages and guidelines from management, but perceived them in a different way than intended. According to Orr, it was through conversations with each other and with customers, and based on expertise that these technicians developed individual interpretations of the received information.

When it comes to how individuals perceive risk, extensive research has been conducted in this domain. Paul Slovic (2000; 2010) and his colleagues (Kasperson et al., 1988; Leiss, 1995; Slovic et al., 2002, Fischhoff and Kadvany, 2011) indicated in multiple studies the difference between the experts' view and the public's view on risks, and demonstrated how among the latter, opinions about various risks may vary based on perceived benefits. When respondents were given arguments in favour of various risks that they earlier indicated as highly dangerous, they changed their beliefs about these risks. As described in the previous paragraph, this phenomenon in which people let their likes and dislikes determine their beliefs about the world (Kahneman, 2011) is called Affect Heuristics. It demonstrates how individuals might have various perceptions concerning risks, depending on the received message or information. However, a divergent perception is not necessary similar to an adapted risk aversive action. In that perspective, Weick and Sutcliffe argue, "it is easier to change someone's beliefs than to change someone's action" (Weick and Sutcliffe, 2007; p.124).

It is not only the case with lay people when it comes to interpreting risk; experts' perceptions vary as well. In his doctoral thesis, Mike Lauder indicates seven different dimensions and eleven definitions of risk (Lauder, 2011). He argues that, for instance, a safety manager and a production manager each have a

distinctive view on the risks that might impact business performance. Therefore, depending on the role or the position in the organisation, “the concept of risk might be conceptualised during risk discourse” (Lauder, 2011; p. 31). Although Lauder focuses on the collective interpretation of risk, he indicates various interpretations of risks in one and the same organisation. Kaplan and Mikes (2012) support this view and present a framework for managing risk, in which they distinguish three risk types (preventable, strategy, and external risks) with distinct mitigation objectives and control mechanisms.

Although these insights give answers to the question how people interpret the same information differently and how risks might be perceived in a varying way, none of the previously mentioned research was conducted in organisations with tightly coupled and complex interactive systems. Nor was it indicated whether these divergent perceptions have an impact on safety attitudes in these types of organisations. Therefore, a deeper understanding of the role of individual risk perceptions and its impact on safety attitudes in tightly coupled and complex interactive organisations is recommended.

2.3 Conclusion

In organisations that deal with complex interactive and tightly coupled systems, the executive team communicates with their staff about the organisation’s mission, vision, and values that aim to contain risks in daily operations. Safety guidelines, procedures, and various tools such as trainings, evacuation drills, emergency exercises, all underline the impact of the potential risks and how to contain them.

On the other side, the external pressure that forces an executive team to contain risks becomes increasingly onerous. Various international and national regulations drive executives to operate according to strict safety directives. From a financial perspective, different interest groups such as boards, insurance companies, shareholders, and clients expect these companies to produce continuously, without being confronted with accidents. Besides these regulatory and financial obligations, these organisations have moral obligations

as well. Their neighbours, the community, their own staff, and the industry they operate in expect organisations to work under strict safety conditions. Multiple scholars (e.g. Leiss, 1995; Leiss, 1996; Perrow, 1999; Slovic, 2000; Gurabardhi and Gutteling, 2002; Gurabardhi et al., 2005; Breakwell, 2007) indicated the increasing regulations and the public pressure on these organisations as one of the main reasons why risk communication was invented.

To get their safety messages across, and more precisely, to have their safety messages acted upon to heed the organisation from potential harm, the executive team will direct middle managers, HSEQ-staff (Health, Safety, Environment, and Quality), and internal or external experts (such as quality controllers, safety consultants, etc.) to support this communication about potential risks and the need for safety behaviour on the shop floor. However, the question could be raised whether everyone in the organisation perceives risk in the same way?

In my daily practice as a consultant in the field of risk management I am confronted with the impression that every staff member has different perceptions of the risks that might endanger the organisation. Thus, it might be quite possible that it has nothing to do with how people communicate risk information, but with how organisational members (both ‘senders’ and ‘receivers’ of information) absorb and perceive the risk that is the topic of the conversation. Therefore, the question could be raised what factors affect this risk perception?

Therefore, this research project raises two questions to approach the described problem:

1. Do people within a complex interactive and tightly coupled organisation perceive the same type of risks differently?
2. If so, what factors affect the perception of these risks?

In the next chapters of Part III of this thesis, I will explain the method, the design, and the results of this research project. In the final chapter, I will discuss the limitations and offer recommendations for further research.

3 RESEARCH METHOD AND DESIGN

In the previous chapter I indicated the rationale for gaining more insights in how different people within a complex interactive and tightly coupled organisation perceive the same type of risk, and what factors affect that perception of risk. In this section I will explain how these questions will be addressed in an empirical research project. The results of this research will be discussed in chapter 4.

3.1 Research method

If we assume that different people in the same organisation have divergent perceptions of the same type of risks in their organisation, there are two plausible options to address this issue in a research project: on an individual or on a collective level. As mentioned before, I will solely focus on the individual level, as this will offer the possibility to gain insights in the way risk perceptions, attitudes and behaviours of individuals within an organisation (Harvey et al., 2002) are individually constructed. Furthermore, insights offered by Dillon and Tinsley (2008) on how individuals' risk perception is rooted in an associative and a rule-based information-processing system, indicate that formal rules of reasoning as well as emotions and interpretations both influence individuals' decision-making processes and safety behaviour (Dillon and Tinsley, 2008). To gain access to these information-processing systems and their impact on individual risk perceptions, a qualitative research method seems to be appropriate, as "good qualitative data are more likely to lead to serendipitous findings and to new integrations; they help researchers to get beyond initial conceptions and to generate or revise conceptual frameworks" (Miles and Huberman, 1994, 1).

In an attempt to address the research questions, Repertory Grid seems to offer the possibility to uncover different constructs concerning risk as perceived by different individuals in an organisation. Repertory Grid stems from the Personal Construct Theory (PCT) as proposed by George Kelly (1955). Kelly believed that, in an effort to make sense of their world, human beings individually

develop constructions or theories of their world in relation to themselves. These constructions are not fixed, but change according to new experiences (Kelly, 1955). If we translate this to this topic of research, i.e. how people within a complex interactive and tightly coupled organisation perceive the same type of risk differently, it means that every time an individual receives some information about risk, he or she will implicitly evaluate this against a previously developed individual construct. This will lead to an interpretation of the risk and an evaluation of the potential danger in relation to himself or herself. By applying Repertory Grid as a research method, it offers the possibility to make unarticulated or implicit individual constructs of sensemaking explicit (Cassell and Walsh, 2004). The Repertory Grid technique is not only a powerful tool that helps respondents "articulate their views on complex issues without interviewer bias" (Goffin, 2002; p. 199), it is also a valuable qualitative method for organisational research in the field of risk analysis (Gammack and Stephens, 1994; Cassell and Walsh, 2004) and management research in general (Goffin, 2002).

The rationales for applying the Repertory Grid technique to this research, rather than other methods, are multiple. First, my assumption is that various individuals in one and the same organisation perceive the same type of risks differently. It might be possible, for example, that the CEO's view of certain risks within the organisation differs from those who maintain the technical installation. The only way to confirm or falsify that assumption is by checking every individual construct regarding risk, based on semi-structured interviews. Repertory Grid therefore offers a suitable approach. Secondly, examining these individual risk perceptions among staff might add an extra dimension to the different perceptions of risk among the organisational members. In other words, it might uncover new risk elements that are undervalued or simply unknown to the organisation. Thirdly, to get a deeper insight into the organisational members' information-processing systems (Dillon and Tinsley, 2008) and how these systems influence the individuals' risk perception, Repertory Grid might help the interviewees to articulate their comprehension of present risks in their own words. And finally, to get a fuller understanding of the risk avoidance

mechanisms at play in a complex interactive and tightly coupled organisation, Repertory Grid offers the possibility to tap into the individual's tacit knowledge, and uncover how sense is made of risks in his or her organisation.

Before deciding to apply the Repertory Grid technique as the most suitable method addressing the research question, I considered other qualitative methods such as ethnography and participant observations, discourse analysis, or focus group interviews. However, as I decided to focus on existing individual frameworks regarding organisational risks, and not collective interpretations of risks, these alternative methods were discounted.

3.2 Unit of analysis

To uncover how different people in a complex interactive and tightly coupled organisation perceive the same risks differently, it would be ideal to examine one hundred percent of the population in one organisation. Doing so might lead to a full and unbiased view of the different individual perceptions at play (Bohnsack, 2004) in that particular organisation. The Belgian receiving gas terminal of Norwegian gas transport company Gassco AS was selected for this research[8]. It is a representative complex interactive and tightly coupled organisation and has a small number of staff (29 in total). This offers the possibility to examine all employees' risk perception individually. Gassco AS is a Norwegian state-owned gas transport company with headquarters and a central operation control room in Bygnes (Norway). Gassco has four EU-continental receiving terminals in Germany (Dornum and Emden), Belgium (Zeebrugge), and France (Dunkirk), and two UK receiving terminals in St. Fergus, and Easington. In total, Gassco AS employs 353 staff. Over the last three years, multiple divisions of Gassco AS faced several critical incidents. Table 3-1 presents the number of incidents at group level in detail.

[8] This company is indicated in Part I of this thesis as 'Gas Receiving Terminal', or 'GRT'.

Incidents at Gassco	2009	2010	2011
Fires:	3	0	2
Gas leaks:	1	2	2
Critical incidents:	5	14	3
Total personal injuries:	24	22	24

Table 3-1 Incidents at Gassco AS on group level over the last three years *(source: Annual Report 2010 and Annual Report 2011)*

The Belgian receiving terminal, which is located in the port of Zeebrugge, handles the total volume of gas that is transported through a 40" pipe (the so-called 'Zeepipe'), with a flow rate of 42 million Nm^3 per day[9]. The gas contains 91.2% methane (DNV Energy, 2010). This terminal remotely controls Gassco's French receiving terminal in Dunkirk, which is responsible for all the Norwegian gas that arrives through the so-called 'Franpipe' (42" pipe), with a flow rate of 54 million Nm^3 per day. The Belgian and French receiving gas terminals jointly handle 26% of the Norwegian gas export (Norwegian Ministry of Petroleum and Energy and Norwegian Petroleum Directorate, 2012). Gassco's receiving terminal in Zeebrugge, the employees of which are the subject of my research, will be further referred to as 'Zeepipe Terminal' or 'ZPT'.

Since 2008, I have worked as a consultant for ZPT in the field of risk and crisis management. My company edited their emergency plans (both for Belgium and France), and we have run multiple safety trainings and crisis exercises over the last years. Due to these experiences I have a fairly good view of the organisation's safety culture, strengths and weaknesses, and I have a trusted and respected position within Gassco's executive management team as well. This unique position resulted in the full support of the Belgian CEO and his executive management team for this research project. Despite my good knowledge of this company and the industry they operate in, there were some

[9] Nm^3 stands for 'Normal cubic meter' and is a common unit used in the industry to refer to gas emissions exchange. It is always dependent on the individual circumstances of each gas, pressure, and use.

issues to tackle before I could start this empirical project as a researcher and not as a consultant. Making a clear distinction between consultancy work and academic research was not easy and had multiple ethical issues. How could I not be biased by my previous knowledge and experience in this company? How could I distinguish academic research from consultancy work? And how would I deal with the results of the research in case they indicate flaws in my previous work as a consultant? All these topics were extensively discussed in advance with both my business partner and with ZPT's CEO. Firstly, we decided to suspend my role as consultant at ZPT for the entire length of the research project. Secondly, we agreed on the fact that this research is free of charge for ZPT and that all expenses (such as transport, translation fees, etc.) linked to this research would be payable by me. Thirdly, all consultancy staff of my company would be excluded from the research process. And finally, ZPT's executive management team agreed to accept my role as an independent researcher. We even discussed the possibility this research might offer recommendations contrary to my company's previous advice. If that would be the case, we agreed to accept it as learning rather than shortcoming.

In the following paragraphs (see: "3.4 Sampling", and "3.5 Data collection") I will elaborate on how we embodied these agreements in the research practice.

3.3 Pilot

Prior to this research at ZPT, pilot interviews based on the repertory grid methodology were held at a chemical production unit of Total Belgium. These interviews took place at the end of February 2012. Total's production unit is a complex interactive and tightly coupled organisation as well, operating in the same industry as Gassco, i.e. the gas and oil business.

At this stage I was examining a slightly different research question. As the outcome of P1, the systematic review, indicates various leadership actions in risk communication, I initially focused on 'good' and 'poor' risk communicators in an organisation and their impact on individual risk perception. Four different profiles participated in this pilot: the CEO, the safety manager, a middle

manager, and an operator. They all attended a brief information session about the aim of the pilot study, its place in the research process, and additional information about research confidentiality. The names of 'good' and 'poor' risk communicators were specific, clear, and offered by the interviewees. Value judgements were also avoided as the question was about good risk communicators, not about good managers or leaders. Although three out of four participants disclosed after the interview that it helped them to articulate their thinking and that somehow they gained new insights, the research results were not completely satisfying. Two out of four interviewees were struggling with the concept of "risk communication" as they mentioned day-to-day communication (formal as well as informal communication) as constructs. Some examples are: "having authority", "pro-active communication", "giving feedback", or "the (mis)use of e-mail". It became apparent that for the interviewees the terms "risk" and "communication" meant different things. This led to the insight that "good" or "poor communicators" are unfathomable concepts to evaluate by the interviewees. However, they were able to express their perceptions of communicative acts. After a discussion with my supervisory panel, we agreed to adapt the focus of the research project to an evaluation of individual risk perceptions rather than an evaluation of risk communicators. Moreover, this was also a major finding of the systematic review of the literature (see Part II, page 159). The research questions were subsequently adapted and relevant literature in the field of individual risk perception was examined (see: "2.2 Perception of risk" on page 174).

3.4 Sampling

The total number of staff at the Belgian receiving terminal of Gassco in Zeebrugge (ZPT) is 29; 4 women and 25 men. Between 23 March and 9 May 2012, 28 individual interviews were held at the premises of ZPT. One staff member was not included in the interviews as this person had been on permanent sick leave since the end of 2011. All face-to-face interviews were in Dutch, the employees' native language. Each individual interview took approximately 50 minutes and was digitally recorded.

The table below (Table 3-2) gives an overview of the participants.

Division	n (men)	n (women)	Age (mean)	Years with Gassco (mean)
Management:	4	0	44.50	15.25
Administration:	2	3	42.60	11.00
Operation Supervisors:	14	0	41.85	12.89
Maintenance:	5	0	49.40	15.00

Table 3-2 Overview of interviewees at ZPT

Concerning the level of education, the dominant group of employees holds a Graduate degree. Only two employees hold an Engineering degree, and no one a Masters' degree (see Table 3-3). It must be indicated that 6 employees indicated they followed extra part-time courses on various topics such as management, prevention advisor, industrial maintenance, administration, or technical skills.

Education level	n
Engineer:	2
Master:	0
Graduate:	12
Undergraduate:	11
Secondary School:	3

Table 3-3 Level of education at ZPT

Prior to the interviews, ethical approval was asked of the Cranfield School of Management's committee and granted. A Confidentiality Agreement between Cranfield School of Management, Gassco Zeebrugge, and myself was signed. This document was based on the school's confidentiality form.

3.5 Data collection

All the 28 interviews were performed in 7 days spread over one and a half months (between 23 March and 9 May 2012). Prior to the interviews, the Gassco staff members who were participating that specific day in the interviews

were invited to a presentation on the research project. In this presentation, the aim, objectives, methodology, and the confidentiality of the interviews were explained. The CEO of ZPT required this briefing, as most of the employees just know me as a consultant, and only a few are aware of my engagement in the Cranfield DBA. These briefings also set the stage to differentiate my role as researcher and not as consultant.

Every interview was digitally recorded and fully transcribed afterwards. All the interviews took place in ZPT's so-called "Permit Room" in Zeebrugge. This is a private room, separated from the control room, where contractors receive their work permits before they start their activities on the plant. The interviews were held by one researcher and observed by a second researcher. Tim Van Achte, a researcher at PM who does not work as a consultant for ZPT, acted as an observer 8 times (on the first day and on the sixth day), Erik Snoeijers, a PhD-student in the field of crisis communication at the University of Antwerp (Belgium), acted as the observer for all the other interviews (14 times) or as interviewer (6 times). I attended all the 28 interviews, 22 times as interviewer and 6 times as observer. The interviews I acted as an observer concerned ZPT staff I was too familiar with. I made this decision to avoid personal biases caused by my engagement as a consultant with this company.

In the first part of the interview, approximately 10 minutes, the interviewee was asked to introduce him or herself, his/her educational background, age, the number of years with ZPT, previous work experiences, and if they ever experienced a crisis situation at work – be it at ZPT or elsewhere. Following Kelly's (1955) triadic method, each interviewee was asked to name three risks at ZPT with high consequences, and three risks at ZPT with low consequences. The interviewee was asked to write each item on a separate pre-numbered card. The cards with 'high consequences' were numbered 5, 1, 6; the cards with 'low consequences' were numbered 4, 3, and 2. Then, the interviewee was asked to explain the six elements and his or her personal interpretation of those risks. By doing so, the intention behind some of the elements became more apparent. 'Fire', for example was to some interviewees linked to gas fire on the

production plant, while others interpreted this as a fire in the building, such as a kitchen fire. The impact of each type is tremendously different. Another illustration is ‘sickness’; one interviewee referred to sickness in the sense of a pandemic outburst of flu that might have an impact on business continuity, while others referred to a single colleague who is ill and needs to be replaced.

The interviewee was then given three cards, a so-called ‘triad’. Six elements offer the possibility to create twenty triads. Prior to the interview, these triads were indicated on the interviewer’s document and were consistent among all interviews. Appendix E shows an example of this document (taken from Interviewee # 14). Based on this triad, the interviewee was asked to look for a specific attribute that combines two risks and that makes those risks distinct from the third risk at the same time. Based on the interviewee’s observations, a construct was proposed by the interviewer. When, for instance, an interviewee divided a triad in ‘Gas leak – Gas Fire’ on the one hand, and ‘Loss of communication between the terminals in Zeebrugge and Dunkirk’ on the other, based on ‘material damage’, the construct ‘No material damage – Major material damage’ was proposed. The interviewee was then asked to grade each of the three elements that inspired him/her for this construct on a scale from 1 (No material damage) to 5 (Major material damage). Subsequently the three other cards were offered and the interviewee was asked to grade them on the scale. The former example was taken from interview number 14. This process was repeated until the interviewee indicated that he or she had no more inspiration, or simply wanted to stop. The number of constructs each interviewee created varies between 5 and 13. No similar constructs were allowed, and constructs that were based on cause and effect were dismissed as well.

At the end of the interview, the interviewer presented the risks with low consequences and the risks with high consequences once more to the interviewee. The question was raised whether the interviewee would change any of the initially chosen elements if he or she could. Only three interviewees

indicated that they would make minor adaptations, all the 25 other interviewees stated that they stick with their initial choices of chosen risks.

3.6 Data analysis

The process of data analysis evolved in multiple subsequent phases. In every phase the two observers assisted in the process of interpreting the data. After the first 21 interviews, preliminary interpretations were made. The data were analysed using the elements offered by the interviewees, the interviewees' constructs, the observers' notes and the full transcription of the tape recordings. This process is illustrated in figure 3-1 and will be explained in detail in the next paragraphs.

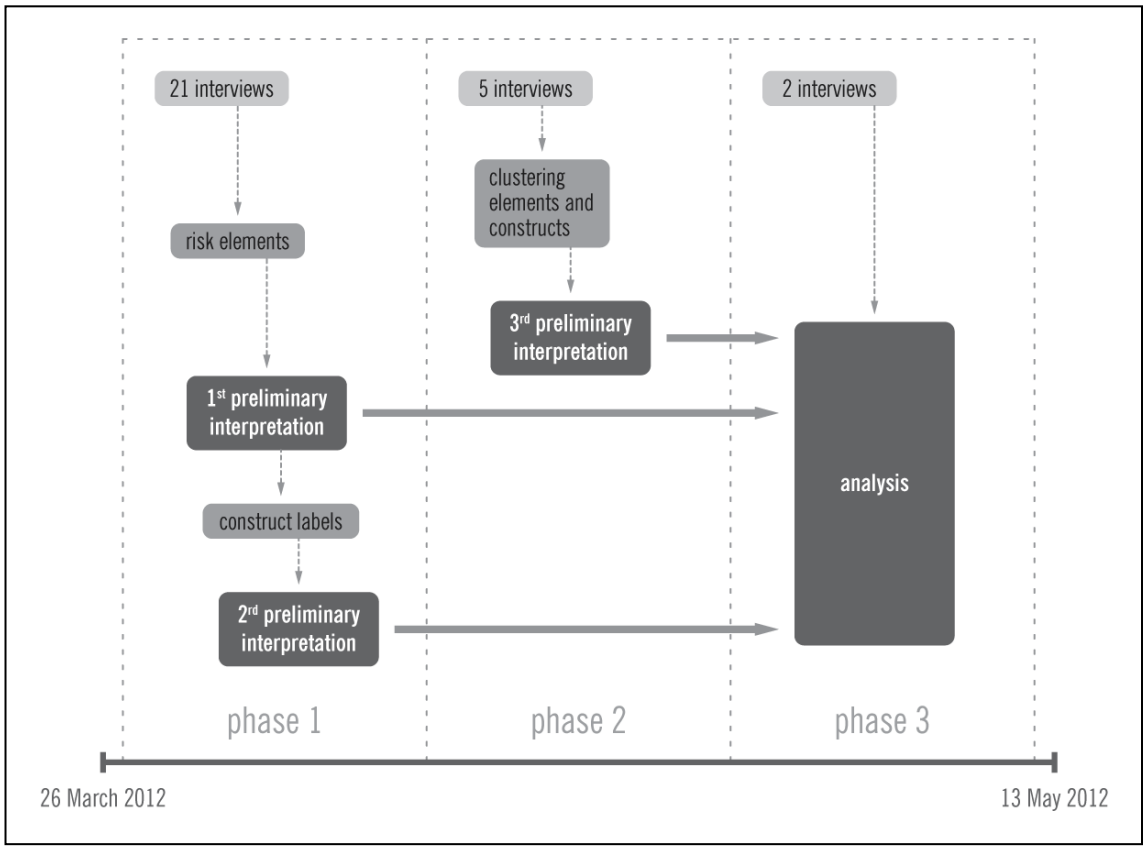

Figure 3-1 Process of data analysis

In Phase I, 126 risk elements (both with high consequences and with low consequences), offered in the first 21 interviews, were labelled into five distinct categories:

A. Risks related to operations (Gas related),
B. Risks related to personal injuries and deaths,
C. Risks related to possible emissions,
D. Risks related to criminal acts,
E. Various risks.

The data was organised into responses that correspond to an already existing ZPT document: the Risk Alerting Matrix (Gassco, 2009). Categories A, B, C, and D refer to this Alerting Matrix; if something in one of these domains happens, the emergency plan will be activated immediately and the crisis team has to meet (Gassco Belgium, 2009). Category E (various risks) contains all the risk elements interviewees mentioned but that do not appear in ZPT's official Alerting Matrix. Then, all the risks from the element groups were divided over the four divisions in the organisation, with respect for the interviewees' interpretation of 'low' and 'high consequences':

- Management,
- Administration,
- Operation supervisors,
- Maintenance.

The role of these four divisions, and how they interpret risk in their organisation will be extensively discussed in chapter 4 (on page 193).

Based on an initial comparison between the data and the transcripts, and a first phase of open coding to assign a conceptual label to each element, the first preliminary interpretations were made. After this, the analysis moved to discovering relationships between the various constructs the interviewees offered in the interviews. These constructs, 178 in total, were labelled into 36 construct codes, and were also assigned to the four groups in the organisation. A second preliminary interpretation based on this extra dimension was made.

In Phase II, both the 30 elements and 47 constructs from 5 interviews were added to the existing data as described in Phase I. It is worthwhile mentioning that three new risk elements were found, and labelled. These elements are

'bribery' (Interviewee #22), 'sound pollution' (Interviewee #23), and 'electrocution' (Interviewee #26).

Then, Category E was subdivided into four types: 1) external risk factors that might impact ZPT, 2) risks linked to facilitating systems, 3) risks linked to ZPT's specific process, and 4) risks linked to behavioural issues. This resulted in the clustering of 42 risk elements groups into eight element types. The 42 risk element groups and eight risk element types are illustrated in Table 3-4. A full overview of all the elements, mentioned by the interviewees and how they are attributed to the various element groups, is presented in Appendix F.

Element types (8)	**Element groups (42)**	
A Fires & leaks	Explosion	Gas leak
	Gas fire	Minor gas leak
	Fire (not linked to gas)	Domino effects
	Damage onshore pipeline	
B Injuries & illness	Death	Maintenance on plant
	Contractors	Sickness
	Human error with physical consequences	
	Personal Protection Systems (PPS)	
C Emissions	Chemical incident	Noise pollution
D Criminal acts	Criminal acts	Financial
E1 External factors impacting Gassco	Image	Closing down plant
	Airplane crash	
E2 Facilitating systems	Equipment	Access
	Maintenance	Banalities
	Technical problems with IT/non operating systems	
E3 Gassco specific process	Mechanical problem	Failure of safety systems
	False alarm	Pressure in pipe system
	Quality Control	Problems with pipes
	Technical error on installation	
	Failure of process systems	
E4 Behavioural issues	Bad communication	Work permits contractors
	Strikes	No response to alarms
	Lack of experience	Safety on excursions
	Human error with technical consequences	
	No timely reporting of malfunctionings	
	Not acting according procedures	

Table 3-4 Risk elements attributed to element groups and types

Then, the list of 225 constructs was clustered into 36 construct groups. These construct groups were clustered into seven construct types. They are:

- Human factors,
- Organisational relation structures,

- Risk and crisis containment,
- Tangible and non-tangible damage,
- Outcome probability,
- Plant and process related,
- Non-human related root causes.

These ‘construct groups’ and ‘construct types’ are presented in Table 3-5. A full overview of all the constructs, mentioned by the interviewees and how they are attributed to the various construct groups, is presented in Appendix G.

Construct types (7)	**Construct groups (36)**	
Tangible & non tangible damage	Image & media	Clients
	Environment	Financial impact
	Material damage	Scale of impact
	Duration of consequences	
Plant & process related	Production process	Pipe pressure
	Gas related	Physical location
Outcome probability	Internal or external consequences	
	Probability specific outcome	
	Probability	
Non human root causes	Work permits	Scale of situation
	Various parameters	
	Flaws, mechanical, electronics	
	Internal or external cause	
Human factors	Experience	Communication
	Intention	
	Human or technical error	
	Material vs. human consequences	
	Physical damage to humans	
	Emotional impact to humans	
Organisational relation structures	Impact on my job	Internal or external staff
	Alarming the hierarchy	
	Operations vs. Management	
	Operations vs. Maintenance	
Risk & crisis containment	Procedures	Prevention
	Help required?	Control
	Escalation	

Table 3-5 Risk constructs attributed to groups and types

The process of integrating the ‘risk elements’ and the ‘constructs’ into ‘element groups’ and ‘construct groups’, and ‘element types’ and ‘construct types’ was the basis for a third preliminary interpretation of the data.

Every step in the process of evaluating the data was made after individual and collective interpretation and complete agreement on the decisions made. The first two preliminary interpretations were made over a six hour session between the researcher and the two observers. All the elements were attributed to a particular category after final checks of the transcripts and personal notes. When for example an interviewee mentioned ‘fire’ as one of the risks threatening ZPT, a distinction had to be made between a ‘non-gas related fire’ and a ‘gas fire’. The third interpretation, when the elements and constructs were clustered into groups and types, took more than six hours. Firstly, there was an individual categorisation where no discussion was allowed and each researcher/observer recorded their coding. Then, the individual categorisations were compared and discussed until final agreement was found.

In Phase III, the data of the final two interviews (12 elements and 16 constructs) was coded according to the labels that were attributed in Phase II. Still, one more new element was offered by the very last interviewee (‘damage to the pipeline outside the ZPT plant’). After 28 interviews, data saturation was attained as the entire active population of Gassco’s receiving terminal in Zeebrugge was interviewed. Then, the process of integration of the three previous preliminary interpretations, and refining the analysis of the data was performed. These findings will be discussed in the next chapter.

4 FINDINGS

4.1 Introduction

The aim of this empirical research is to evaluate the staff's individual risk perception in an organisation with complex interactive and tightly coupled systems. To do this, the design of this research was set up in a way to access the staff's perception in comparison to the company's official risk matrix.

The Zeepipe Terminal (ZPT), like all of Gassco's installations, has various safety and recovery plans. They are not only required by the government, but are also an integral part of the company's overall safety values. Prior to the research, I examined various safety and business continuity plans for ZPT (Gassco, 2009; DNV Energy, 2010; Gassco, 2011; Gassco, 2012). These documents contain lists of external and internal risks to the operations at ZPT. Each of the risks has been evaluated in terms of potential fatal victims, damage to the installation, and impact on production and environment. Based on interpretations of probability and potential outcome, Gassco's management installed and communicated an alerting matrix. This matrix contains four large domains of potential risks at ZPT: 1) fire and gas leaks, 2) injuries and sickness, 3) emissions, and 4) criminal acts (as presented in Figure 4-1). Each of these domains is covered by multiple Standard Operating Procedures (SOPs) and Standard Operating Guidelines (SOGs) that aim to control, mitigate or avoid potential harm[10]. In all, there are 247 SOPs and 300 SOGs in use at Gassco. All these procedures and guidelines are accessible through the intranet, and the majority are about the safe use of tools on the plant. Table 4-1 presents the number of procedures and guidelines linked to each of the four risks in the ZPT Risk Matrix. 'Level 1' has to do with corporate governance processes, such as audits, reviews, and business plans. 'Level 2' are directives that are initiated by Headquarters (HQ) in Norway and deal with working environment, management, and performance. The 'Level 3' directives are installed by HQ and

[10] Not all the SOGs and SOPs are directly linked to operational risks. Many of them are job descriptions and guidelines to secure the supply of office stationery or even toilet paper, for instance.

apply to all Gassco staff and gas receiving terminals. They are more focused on safety operations, asset management, and emergency responses. The final group of SOPs and SOGs are local directives linked to authority relations, security management, and fiscal processes. Although Gassco indicates four large domains of risks for their 'Risk Alerting Matrix', all of the four levels of directives are equally important. It might be clear that 'injuries' outscores the other four risk domains when it comes to the number of procedures and guidelines ZPT has in place to prevent staff from being injured. In contrast, 'criminal acts' has the lowest score regarding procedures and guidelines.

	Fires	Injuries	Emissions	Criminal acts
Level 1 – Corporate Governance	4	4	6	1
Level 2 – HQ directives	8	9	16	6
Level 3 – Gassco all & All terminals	5	9	4	3
Local Directives (ZPT)	26	32	22	12
Sub total	*43*	*54*	*48*	*22*
Guidelines	7	28	16	6
TOTAL	**50**	**82**	**64**	**28**

Table 4-1 Number of procedures and guidelines linked to Risk Matrix

The procedures and guidelines linked to these four risk domains, as presented in Table 4-1, are the subject of formal trainings that each employee (including administrative staff) receives once a year at the so-called HES days (Health, Environment, Safety). The HSEQ manager or external consultants in various fields of risk and crisis containment conduct these trainings. Besides these formal trainings, my experience with ZPT indicates that a lot of informal conversations about safety and potential risks are discussed among staff members on a daily basis. As this is a rather small organisation, everyone seems to talk to everyone. On several days I witnessed how maintenance workers were sitting at a large round table over lunch, having a chat with the CEO and other colleagues about various topics (i.e., about the new safety fence

that was under construction, or about a minor incident at one of the other gas receiving terminals).

All staff is expected to know these risks and the affiliated procedures, and to anticipate them in case of an emergency. In trainings, exercises, and safety meetings, every staff member learns how to detect, interpret, and alert the on-call duty manager. It is each person's task to evaluate the situation, and -if required- activate the crisis team (Gassco Belgium, 2009).

To evaluate the individual risk perception of ZPT staff, the four domains described in this risk matrix (presented in Figure 4-1) were used as the company's own risk standards.

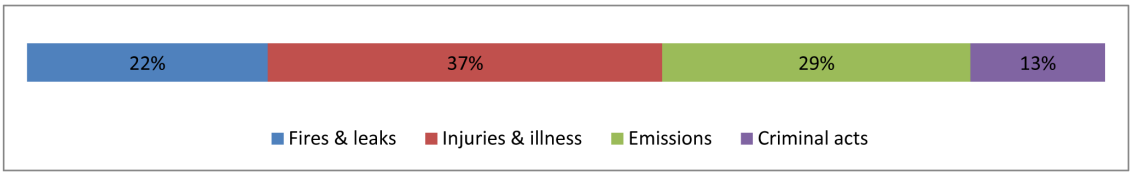

Figure 4-1 Risk domains covered in the ZPT Risk Matrix

As described in chapter 3 of this part of the thesis, each individual at ZPT was asked to name three risks in their organisation with high consequences, and three with low consequences. Figure 4-2 illustrates the staff's overall perception concerning risks with high consequences and both risks with high and low consequences at ZPT.

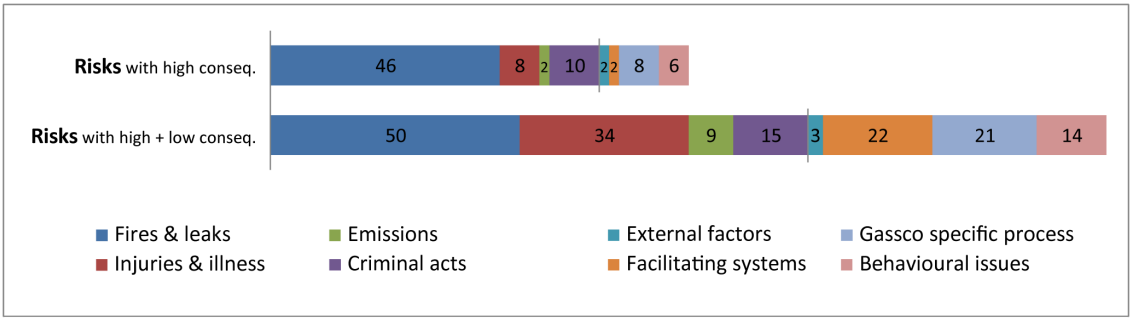

Figure 4-2 Overall risk perceptions at ZPT

The numbers on the bar graphs indicate the actual number of mentions. As 28 individuals were interviewed, the perceptions of risks with high consequences

are based on 84 elements (3 x 28) and the perceptions of risks with low and high consequences are based on 168 elements (6 x 28).

A first observation is that all the four risks from the alerting matrix (see Figure 4-1) appear in the overall risk perception diagram, be it not in the same proportion. Secondly, the bar chart with low and high consequences has a less extreme distribution of the risk elements than the diagram with solely high consequences. However, in the former, risks linked to the domains 'fires & leaks', 'injuries & illness', 'facilitating systems', and 'Gassco specific process' are dominant. Thirdly, I would argue that only the diagram with risks with high consequences might be compared to the official alerting matrix as this matrix is only suitable for risks with high consequences and not for minor injuries or damages. In that case, 'fires & leaks' completely outscores the other risk elements. And finally, we must point out that the group of Operation Supervisors has a dominant voice in this overall picture, as they comprise 50% of the total population at ZPT.

Based on the various risk elements, every individual was asked to reflect on constructs that differ or combine some of the mentioned risk elements. This leads to seven construct types, based on 36 construct groups or 241 constructs. Figure 4-3 gives an overview of these construct types distributed over the entire ZPT population.

An overall observation is that 'Human factors', 'Crisis and risk containment', and 'Tangible and non-tangible damage' are the dominant construct types.

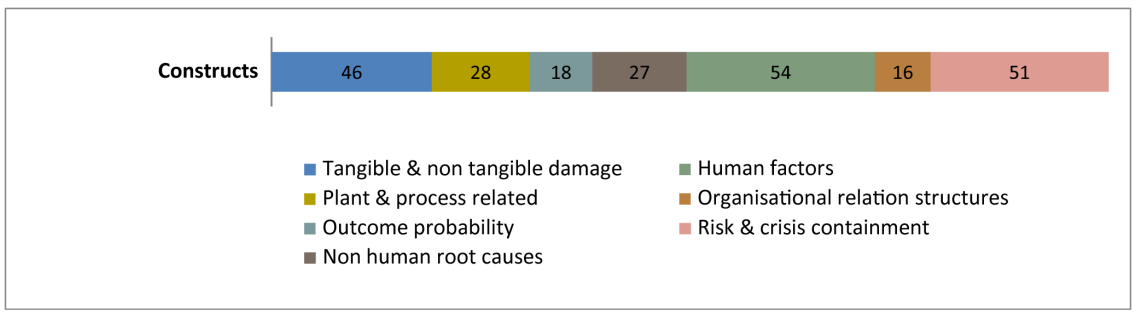

Figure 4-3 Construct types linked to general ZPT population

The aim of this research is to uncover individual perceptions regarding risks in the organisation. In an attempt to present the data comprehensibly, individual perceptions are clustered and presented by the teams. Hence, the following sections will explore the commonalities and differences in risk perceptions among four distinct groups at ZPT: management, administration, maintenance, and operation supervisors. These four groups and their places in the organisation's structure are presented in Figure 4-4.

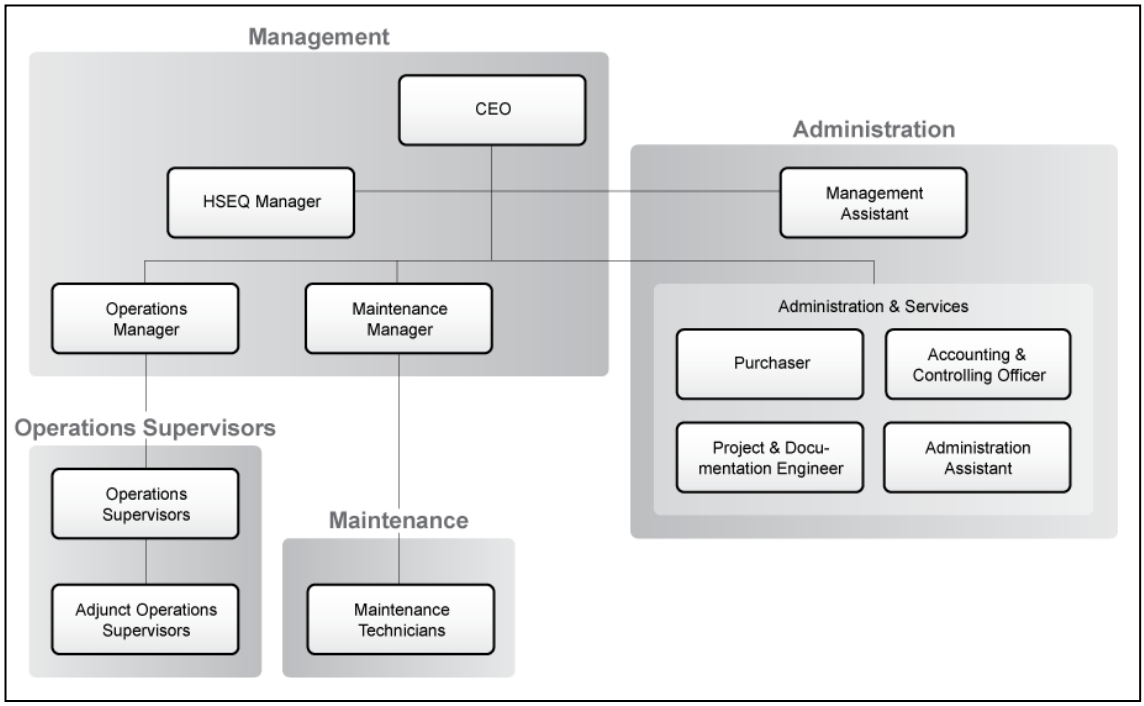

Figure 4-4 ZPT's organisational structure

While being vigilant not to interpret the data as the organisation's vision on risk, nor its attitude towards safety behaviour, the objective of the following subsections is to present the data in a clear and comprehensible format, and indicate significant similarities and differences between the interpretations of various risks in the organisation. An in-depth discussion about the interpretation of these findings and the contribution of this research will be presented in Chapter 5 of this part of the doctoral thesis.

4.2 Management

The management team comprises four people: the CEO, the Operations Manager, the Maintenance Manager, and the HSEQ Manager (Health, Safety, Environment, and Quality). They are all male, between 34 and 56 years of age, and have been with the company between 7 and 20 years. The average number of years of experience in tightly coupled and complex interactive organisations (ZPT included) is 21 years. Two of the management team members hold an engineering degree.

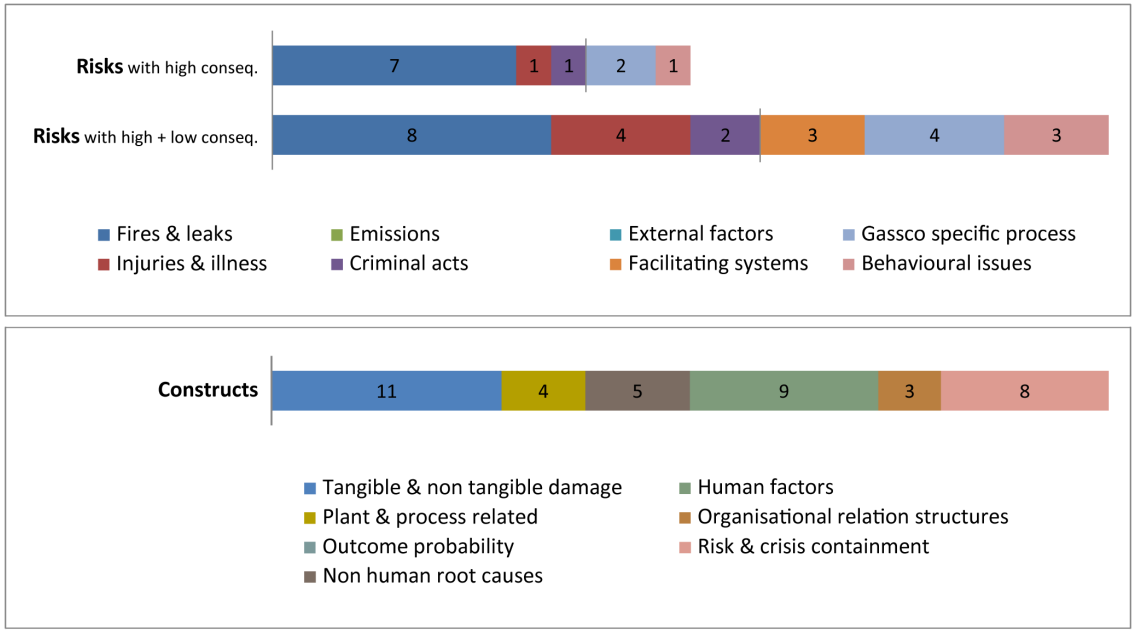

Figure 4-5 Repertory grid results on Management level

A first observation is that the management team members' view on 'risks with high consequences' predominantly refers to their main activity: gas (see Figure 4-5). More than fifty percent of the elements (7 out of 12) mentioned by the management team as risks with high consequences are in the domain of 'Fires & leaks'. This is not really a surprise as gas is the core business of this company, and without doubt one that potentially contains multiple risks. However, it is not proportional to the number of procedures and guidelines concerning the prevention of fires and gas leaks.

A second observation is that only one interviewee mentioned “a deadly accident” as a risk with a high consequence, while ‘Emissions’ was not mentioned at all. Although ‘Injuries & illness’ and ‘Emissions’ both appear in the Alerting Matrix which was approved and disseminated by themselves in the 2009 Emergency Plan (Gassco, 2009), it is not reflected in the interviews. However, looking at the constructs, it provides a slightly different perspective. Multiple constructs were based on ‘Human factors’, such as “safe situation for our staff”, “impact on personal and social life”, “level of stress”, “emotional vulnerability”, or “an accident with physical consequences”, just to mention a few. This compensates for the low score in the elements diagram on ‘Injuries & illness’. The same applies for ‘Emissions’. Concerning the constructs, almost all management team members mention ‘impact on the environment’, which is absorbed into the construct group ‘environment’ and is part of the ‘Tangible & non-tangible damage’ construct type.

And finally, one interviewee called “serious personal accident” a risk with low consequence, while another member of this group was unable even to come up with risks with low consequence. Instead, he mentioned a couple of banalities such as “a broken coffee machine”, or “a broken chair in the conference room”. Concerning the constructs, this group is the only one that did not mention outcome probabilities.

4.3 Administration

The administration team comprises five persons; two administrative assistants, a management assistant, a project and documentation engineer, and an accountant and controlling officer. The three female and two male members of this team are between 28 and 53 years of age, and have been with the company between 5 and 20 years. The average number of years of experience in tightly coupled and complex interactive organisations (ZPT included) is 13 years. Two of the administration team members hold a graduate degree, the three others hold undergraduate degrees but acquired task specific knowledge through various certificated courses.

Closer inspection of the diagrams in Figure 4-6 shows that in ‘risks with high consequences’ and ‘risks with high and low consequences’ the proportion of elements linked to ‘Criminal acts’ is considerably high.

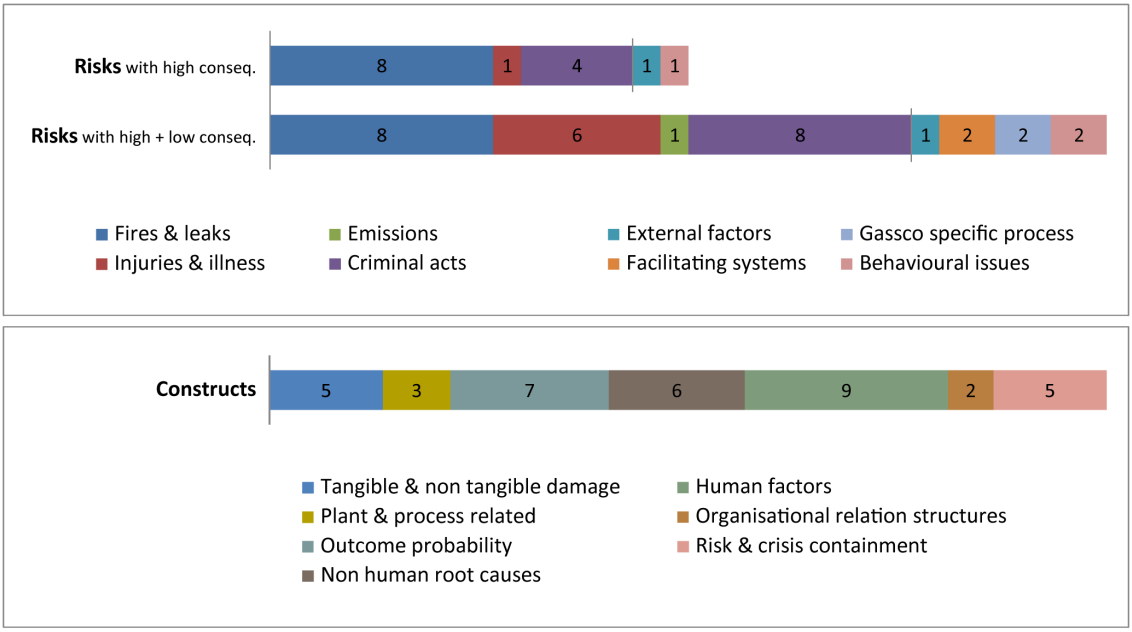

Figure 4-6 Repertory grid results on Administration level

In comparison to other groups at ZPT, the administrative team is remarkably more concerned about criminal acts than any other team. This high number of references to ‘Criminal acts’ could be ascribed to the fact that the majority of this team followed a one-day anti-terrorism course at the end of 2011 (a couple of months prior to this research). A UK expert on explosives and anti-terrorism gave this training, and it was set up very realistically. The participants were first told that a real bomb had been hidden on the premises. Then, they were instructed how to recognise strange objects, and how to deal with threatening situations. They were subsequently asked to go out and search for an explosive package. It is worth noting that one group, including four administration team members, followed this course the day after a deadly attack took place in Belgium. At a Christmas market in Liège, a man shot at the crowd enjoying their Christmas shopping. Six people, among them two teenagers and a baby, were instantly killed. Maybe the timing of this anti-terrorism course, in combination with the very realistic approach of the trainer, might explain why the members of

this team mentioned ‘Criminal acts’ so often, both as risks with low and high consequences.

A second observation is that the administration team members do not mention ‘Emissions’ as a high risk, and only one interviewee mentioned it as a risk with low consequences, more specifically ‘noise pollution’. This might be surprising as ZPT is a very silent plant in a quiet area of the port of Zeebrugge. The motivation for offering ‘noise pollution’ as a risk with low consequences, however, was a personal one:

> *“When the diesel generator starts up, in case of an electricity outage for instance, it makes a lot of noise. And I sit close-by it. In fact, all noise bothers me.” (Interviewee #23)*

A third observation is that this team mentioned all the elements in the category ‘Fires & leaks’, except ‘Minor gas leak. However, none of the administration people will be physically exposed to these risks in case of a possible emergency because they are all relatively safe inside a heat resistant building.

A fourth observation is linked to the risks concerning ‘Injuries & illness’. Here, the risks with low consequences are predominantly linked to minor injuries as a direct result of not wearing personal protection equipment *(“using your equipment in a wrong way”*, Interviewee #12; *“a contractor who’s not wearing his protective clothes”*, Interviewee #11), or to general health issues *(“health of staff”*, Interviewee #4; *“illness”*, Interviewee #12). It is worth mentioning that one of the colleagues of this team, a young woman, was suddenly diagnosed with an aggressive cancer late 2011. This was a shock for the entire company, but more specifically for her colleagues at the admin department. Therefore, the large proportion of constructs under ‘Human factors’ is not surprising. The following quotes illustrate this:

> *“If something were to happen to one of my colleagues, it would have a big impact on me - more on an emotional level - than if something were*

to happen to a contractor. My colleagues are closer to me, you see." (Interviewee #4)

"We all have a good insurance policy, and a regular check up with a GP, but still … serious things can happen to your health. It gives me a hard time when people struggle with their health. People do get older, or something unexpected might happen. It can happen to all of us…" (Interviewee #4)

"When someone feels sick, this normally has no major impact. In most cases, people who are on sick leave will be replaced or the situation will be dealt with." (Interviewee #12)

"Stress might impact you; you get a sudden call when someone falls sick, when there is a strike or a fire. How do you deal with emotions? How much stress can you handle, I mean, to be productive." (Interviewee #21)

4.4 Maintenance

The maintenance team comprises five persons; three blue-collar workers, one person who is responsible for maintaining the IT and electronic systems, and one person responsible for all electronic tools and measurement. They are all male, between 46 and 53 years of age, and have been with the company between 7 and 20 years. The average number of years of experience in tightly coupled and complex interactive organisations (ZPT included) is 20.2 years. Two of the maintenance team members hold a graduate degree, two an undergraduate degree, and one a secondary school degree. One blue-collar worker in this team declared that he experienced a life-threatening crisis situation in his previous job.

Closer inspection of the diagrams in Figure 4-7, remarkably show that the maintenance team members do not denote 'Emissions' nor 'Criminal acts' as 'risks with high consequences'. It is, however, one of their dedicated tasks to check the plant for anomalies in the production process, at the installation, or on the premises. Nor did any of the maintenance team members mention 'Minor

gas leak' as a risk. A minor gas leak is extremely difficult to detect in a control room, as it has no measurable impact on the production process. Therefore, maintenance staff particularly have to be extremely vigilant for minor leaks.

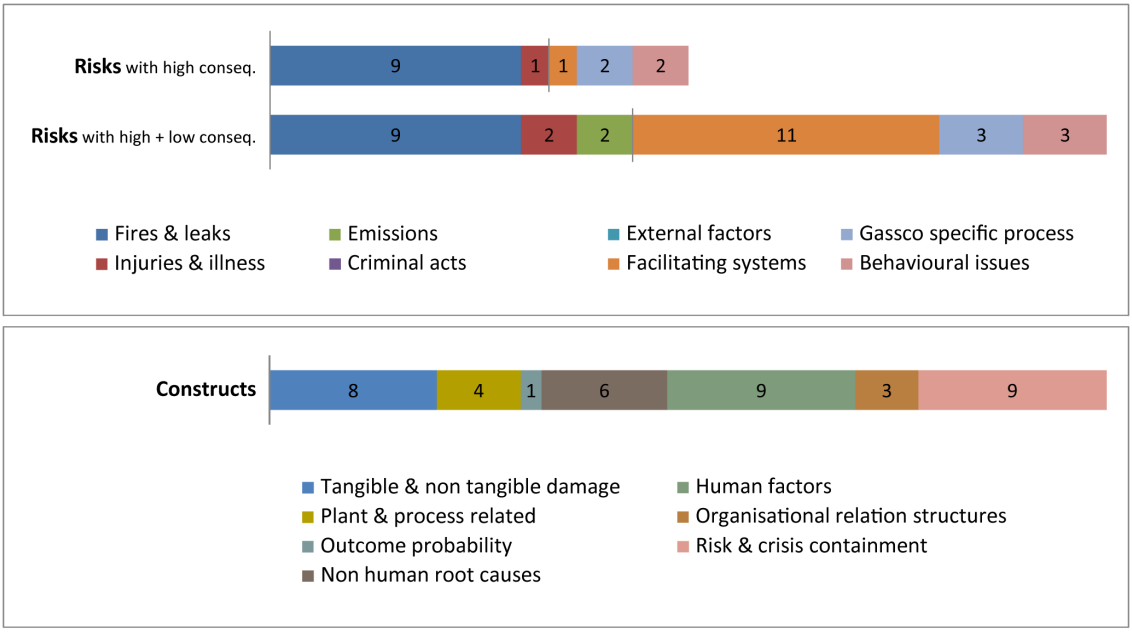

Figure 4-7 Repertory grid results on Maintenance level

Another remarkable observation is that only one of the maintenance staff members mentioned an element that fits the 'Injuries and illness' element type as a risk with high consequences. This is at odds considering that, of all ZPT staff, the maintenance people are predominantly exposed to injuries caused by tools, leaks, or the perils linked to a gas plant. This interviewee (#20), who mentioned an element that fits 'Injuries and illness', referred to possible harm to third parties, not maintenance staff. Furthermore, he unequivocally suggests that the cause of a specific personal injury lies in other people's unsafe precautionary actions.

> *Interviewee #20: "When we have to open a specific part of the installation for maintenance, and it is not free of gas it's a major risk to us. For those who have to open this."*
> *Q: "And what is it you have to open? Can you be more specific?"*
> *Interviewee #20: "A part of the gas installation. And when it needs an inspection or a specific intervention and they (note of the researcher: he*

nods his head towards the control room, which is where the operation supervisors work) haven't vented the pipeline well, or it's not properly rinsed, … or someone forgot to check for gas residues…"
Q: "So you are talking about a part that needs a maintenance check, but is not free of gas?"
Interviewee #20: "That's right."
Q: "And what might happen then?"
Interviewee #20: "It happened once. A contractor was here on the plant to open a flange of one of the process trains. He had all the necessary work permits. They started to unscrew the flange and there was still … I am not saying there was huge pressure, but still enough gas pressure in that pipeline."
Q: "What happened?"
Interviewee #20: "It was a large flange, 24 inches. Those things don't loosen at once. You have to unscrew them slowly. At a certain moment the flange opens and gas pours out. You stop all activities immediately. But this could be prevented. What happened? I don't know. And I'm not going to blame anyone, but someone should have checked the pipe before the maintenance work. That's the job of … (note of the researcher: he nods his head again towards the control room)."

One might interpret that maintenance staff suffer severely from hubris as they completely neglect two out of four risk groups that are denoted by Gassco's official risk alerting matrix. This attitude might be attributed to a typical male attitude among blue-collar workers, where *"boys don't cry"* (Interviewee #19), and where comparing wounds seems to be an indication of being tough and skilled. Or as one interviewee expressed it:

> *"A cut or a small eye injury, that's not too bad. I once got a drop of nitric acid in my left eye. It's no fun, but it is not the end of the world! A good rinse and it was better." (Interviewee #20)*

Although the members of the maintenance team neglect elements that refer to the 'Injuries & illness' type, the constructs they offered indicate multiple facets of

human factors that suggest a severe awareness of possible injuries. A few examples are “impact on staff members’ ergonomics” (Interviewee #15), “consequences for human beings” (Interviewee #16), “potential victims” (Interviewee #20), and “creating human suffering” (Interviewee #28).

Finally, it is not surprising that this group of maintenance people indicate many risks that are categorised under the ‘Facilitating systems’ element type, such as technical problems with IT systems, problems with non-operating systems such as air-conditioning, or issues with technical equipment and tools. These are all typical issues maintenance staff has to deal with.

4.5 Operation supervisors

The operation supervisor’s team comprises fourteen people; seven operation supervisors, and 7 deputy operation supervisors. They are all male, between 29 and 55 years of age, and have been with the company between 1 and 20 years. The average number of years of experience in tightly coupled and complex interactive organisations (ZPT included) is 19.6 years. Five of the operation supervisors hold a graduate degree, seven an undergraduate degree, and two a secondary school degree. Five people in this team declared they experienced a life-threatening crisis situation in their previous job.

The operation supervisors’ habitat is the control room. This room is located centrally in the ZPT-building. It has no windows, but a large video wall that shows all the processes and images of the multiple control cameras on the premises, both in Zeebrugge and Dunkirk.

The operation supervisory team is the only group at ZPT that works in shifts, as the control room operates 24/7. The main role of the operation supervisors is controlling the gas flow in both receiving terminals (Belgium and France). Or to say it in an interviewee’s words:

> *“Our only job is to follow the process, and notify alerts! But, the issue here is that alerts are not always 100% clear.” (Interviewee #5)*

When they discover an anomaly in the production process, they can rely on their colleagues from the maintenance team to go on the plant, check the problem, and fix it. However, in case something happens at night or over the weekend, the operation supervisors or their deputies have to leave the control room and go outside to check and fix the problem themselves.

Due to this technical and practical knowledge of the gas-receiving terminal, the operation supervisors have a fairly good view of all the existing risks. This is reflected in the diagrams as presented in Figure 4-8.

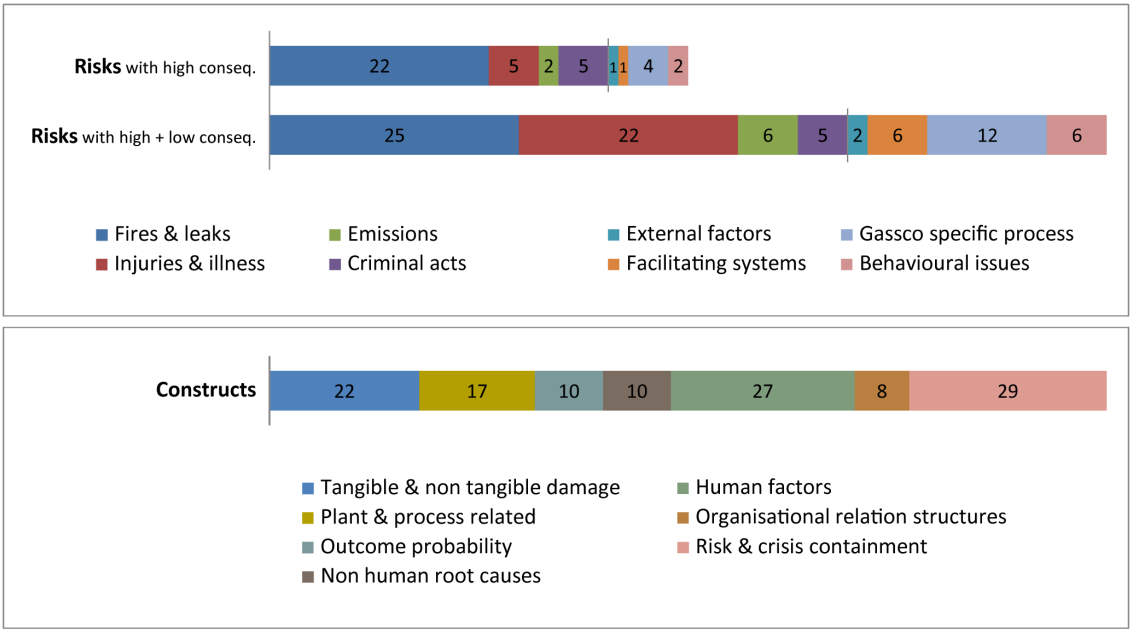

Figure 4-8 Repertory grid results on Operation Supervisors level

A first observation is that operation supervisors have the broadest distribution of risk elements and constructs compared to the other three groups at ZPT (management, administration, and maintenance). This might be accredited to the fact that the operation supervisors represent 50% of the total population of staff at ZPT, and therefore simply attribute more risk elements. On the other hand, it might be attributed to the fact that the operation supervisors have an overall view in every sense (with CCTV images and real-time data) on each and every detail that happens at ZPT. This notion of having a 'broad picture' of the plant, in combination with many years of experience, might also explain why this group of operation supervisors has the broadest view on existing risks at ZPT.

A second observation is that the share of element types in ‘Injuries & illness’ is considerably higher than in any of the other three teams. In combination with a large number of constructs in the domain of ‘Human factors’, this indicates their concern with personal injuries among co-workers.

A third insight is that this is the only team that mentions emissions as a risk with high consequences: ‘Water-glycol’ and ‘To inert with nitrogen’ are both chemical risks linked to the production process that were mentioned by Interviewee #9. Among the risks with low consequences, other operation supervisors mentioned a “leak at the water-glycol system” (Interviewees #10, 26, 27), as well as “working with chemicals” (Interviewee #10).

In contradiction to management and maintenance, which talked about procedures, it is remarkable to observe how operation supervisors predominantly talked about control. This issue of control was linked to contractors “who are difficult to control” (Interviewees #3, #4, #5) “as they easily neglect safety rules” (Interviewees #6, #8), or “who neglect to return their work permits after finishing their intervention” (Interviewees #3, #8). The issue of control was also used in the context of “monitoring access to the premises”:

> *“Quite often it happens that someone is in the building, for a meeting with management for instance, and we are not aware of this. It’s not the end of the world, but … When we see someone walking on the plant, in between the installations, and we don’t know who it is and what he’s doing, you have an issue of not having control over access to the plant.” (Interviewee #5)*

> *“The remote access to the plant in Dunkirk often does not work adequately, but apparently no one worries about it.” (Interviewee #8)*

Similar to some of the maintenance staff, some of the operation supervisors also point the finger to others when it comes to neglecting safety rules. The following interview excerpt illustrates this:

"Recently there was an adjunct supervisor who responded to an alarm as follows 'Oh, it's only air, nothing to worry about.' I replied: 'No, it is not! This is important!' Not informing your colleague about the smallest anomaly might bring you in danger. It's a pity this didn't happen in another shift; they could have seen the consequences of neglecting an alarm."

Q: Am I correct in thinking that not everyone takes alerts as seriously as you?

A: "Yes, it depends on the person. Something can happen any minute. I can't stand it when I arrive at my shift, and I see alerts from three days ago no one responded to. That has happened too often." (Interviewee #5)

A deputy operation supervisor's answer to the request to come up with three risks at ZPT with high consequences, reinforced Interviewee #5 by saying:

"A risk, somehow, is something that isn't easily going to happen, I guess. Normally…" (Interviewee #6)

4.6 Conclusions

As mentioned earlier, we have to be vigilant not to interpret these data as the organisation's vision on risk or its attitude towards safety behaviour. The research aim was to uncover individual perceptions regarding risks in the organisation, not to evaluate individuals' or teams' behaviour. Uncovering perceptions does not reveal whether someone is knowledgeable or sensitive to detect actual risks when they emerge.

Although there is a remarkable feeling of connectedness among staff (in terms of belonging to a group you know very well and fully trust), quite a number of employees indicate a low feeling of ownership regarding their responsibility in the organisation. Often, employees look towards management or headquarters (systematically indicated as 'Norway') to fix a problem when it arises.

“If there is a fire, management will be alerted immediately. They will decide what actions need to be taken.” (Interviewee #11)

“*We have to report every issue to Norway. However, and now I’m walking on very thin ice, there is a difference between what we have to do and what we actually do. In practice we don’t always alert Norway.” (Interviewee #13)*

“We depend on Norway. We execute what they say. If we observe minor issues, such as a broken computer screen, we’ll fix it and just notify Norway. When it concerns major issues, the server for example, we have to rely on Norway.” (Interviewee #15)

Therefore, the question could be raised if this attitude reflects a schism between what these employees experience as risks, and what Gassco advocates as risks. Or in other words: it is not clear whether employees with a fairly good knowledge of existing risks at ZPT also have the practical skills to intervene in the event of an emergency.

Examining all the constructs, it shows that those who are directly involved in managing risks (management, operation supervisors, and maintenance staff) neglect or minimise ‘Outcome probability’ as a construct. While among the members of the administration team, who have no direct impact on the processes, ‘Outcome probability’ is the second highest mentioned construct. According to Kahneman, the concept of probability has been developed by logicians and statisticians, while for “laypeople […] probability is a synonym of likelihood in everyday language” and thus “a vague notion, related to uncertainty, propensity, plausibility, and surprise” (Kahneman, 2011; p. 150). Therefore, this different perception concerning ‘Outcome probability’ between the administration team and the rest of the organisation might suggest that those who manage risks predominantly perceive them in terms of impact on production and safety, while those who are dependent on others to handle risks look at it in terms of the chance that something might happen.

And if we consider all the risk elements, it becomes apparent that firstly there are different perceptions of risk among all organisational members, which vary among the four groups at ZPT. And, secondly, only one group – the operation supervisors- mentioned all the risk elements that are part of Gassco's official risk alerting matrix.

In the next chapter I will elaborate on the nature of these findings, and uncover the factors at play that create this broad view on risks. This will be linked to the existing literature and claims to new contributions to knowledge will be made. Finally, limitations to this research will be discussed, and viable recommendations for practice and further research will be indicated.

5 DISCUSSION

5.1 Introduction

Although several risk communication theorists (Kasperson et al., 1988; Klein et al., 1995; Slovic, 2000, 2010; Coan, 2002; Hambach et al., 2011) have proposed that communicating risk issues might have an impact on risk perceptions, relatively little empirical work has been done to demonstrate the extent to which this risk communication has an impact on individual risk perception among staff in organisations managing high-risk technologies. This research attempts to fill this gap. Through repertory grid analysis I examined each staff member's individual perception of the existing risks and how this differs from the company's official risk matrix, as communicated in the organisation. Next, these individuals were grouped according to the role they play in the organisation, and the data was analysed and interpreted in terms of 'work groups' rather than just the individuals. This led to the finding that there was a certain consistency within these groups, and how these groups perceive risks differently.

In the next paragraphs I will interpret the findings and link them to the existing literature. By doing so, I will provide a contribution to the literature on risk perception.

5.2 Interpretation of findings

This research indicates that all staff members have a different perception of the actual risks in their organisation. It is remarkable to denote that not two employees mentioned an identical set of risks, and none of the staff members indicated the company's official risk matrix. These observations lead to the following questions:

- How is it possible that, despite all organisational members having a different perception of the risks, this organisation operates in a safe way?

- What are the factors that influence the organisational members' individual risk perception?
- Is communication the best tool to adjust risk perceptions and encourage staff to be aware of safety and potential risks?

These questions will be discussed in the following paragraphs.

5.2.1 Equifinal meanings

ZPT has never experienced a severe crisis situation since its inauguration in 1992. They had a couple of unexpected shut downs over the last years, and nothing more severe than bruises and minor personal injuries. It might be argued that this plant could not operate for 20 years without any crisis situation while all the employees have various interpretations of the actual risks. As we know, the average amount of years staff is with this company is 13.5 years, and 43 percent of staff has been with this company since the very beginning back in 1992, we can argue that it is not pure luck that has prevented ZPT from having a severe accident. As a team, despite the different individual perceptions of the actual risks at ZPT, the organisational members seem to operate in a safe and risk aversive way.

This might be linked to the concept of 'equifinal meanings' (Donnellon et al., 1986) for different interpretations of a message, but similar behavioural implications. Donnellon's research indicated that, although organisational members collectively act in the same way, each of them has a different understanding of the conveyed information. This concept of equifinal meanings is partly based on Weick's theory of sensemaking (Weick, 1979; 2005) in which employees basically have two alternative sets of organising mental tools at their disposal: (1) shared meanings and (2) shared communication mechanisms. Based on the data, Donnellon et al. suggest that "meaning and action are related in a complex iterative process in which meanings are continually constructed and destroyed as more sense-making communication occurs and new actions are taken" (Donnellon et al., 1986; p. 53). Although I was not researching individual perceptions regarding risks in action, my research

indicates that despite the fact all organisational members have a different interpretation of the actual risks, they operate in the same safe way.

This leads us to the following two questions, one about the factors that influence the organisational members' individual risk perceptions, and one about alternative tools to adjust risk perceptions and encourage staff to be aware of safety and potential risks.

5.2.2 Crisis experience as dominant predictor

In this research, various parameters were checked to identify plausible factors that influence risk perceptions. From the literature we know that trust in the communicator (Conchie and Burns, 2008; Schoorman et al., 2007), social group relationships (Kasperson et al., 1988), domain familiarity (Gutteling, 1993), and heuristics and biases (Kasperson et al., 1988; Kahneman, 2011) all have an impact on how individuals perceive risk. However, all of these findings are based on research among civilians, and not with staff in organisations managing high-risk technologies.

It can be argued that trust between the communicator and the receiver of risk information at ZPT is relatively high. It is a small group of colleagues (29 in total) that have known each other for a long time: 13.5 years on average, and almost 50 percent of them for 20 years. None of the 28 interviewees mentioned an element that indicates bad intentions or a lack of confidence in the words and actions of their colleagues. In a few cases operation supervisors and maintenance staff were finger-pointing each other with regard to neglecting safety rules. It is my interpretation that this was not an expression of distrust, but rather an effort to underline how good they know the risks and safety rules themselves in comparison to others. On the other hand, the question could be raised whether this high level of trust at ZPT is weakening the organisation from a safety perspective. Based on earlier findings by Conchie and Donald (2006) who studied the role of trust and distrust in a similar type of organisation, i.e. an offshore gas installation operating on the UK Continental Shelf (Conchie and Donald, 2006). They revealed how attitudes of distrust "such as checking and

scepticism have a functional role of ensuring a safe work environment" (Conchie and Donald, 2006; p. 1158).

Concerning social group relationships and domain familiarity it can be argued that the majority of staff at ZPT has a similar educational background (12 undergraduates, 11 with a graduate degree, only two engineers, and no one with a Master's degree), and a large group shares common work experience, as 12 out of 28 were among the first employees who started working at this terminal back in 1992.

When it comes to heuristics, however, there is a significant dissimilarity between the employees who had witnessed a life-threatening crisis situation at their previous job, and those who had not. Almost a quarter of all employees (6 in total) indicated they once experienced a severe crisis situation, such as a fire on board of a ship, an explosion at a chemical plant that killed three blue-collar workers, an emission of a highly toxic product (H_2S), or the safety operations at the Herald of Free Enterprise (a ship that capsized on the night of 6 March 1987, moments after leaving the Belgian port of Zeebrugge, killing 193 passengers and crew).

Five of them are operation supervisors, and one is a member of the maintenance team. Together, they mentioned 36 risk elements, whereas 15 risks are directly linked to their experienced life-threatening situation. Figure 5-1 gives an overview of the differences between the different ZPT-employees who experienced a crisis situation and those who did not.

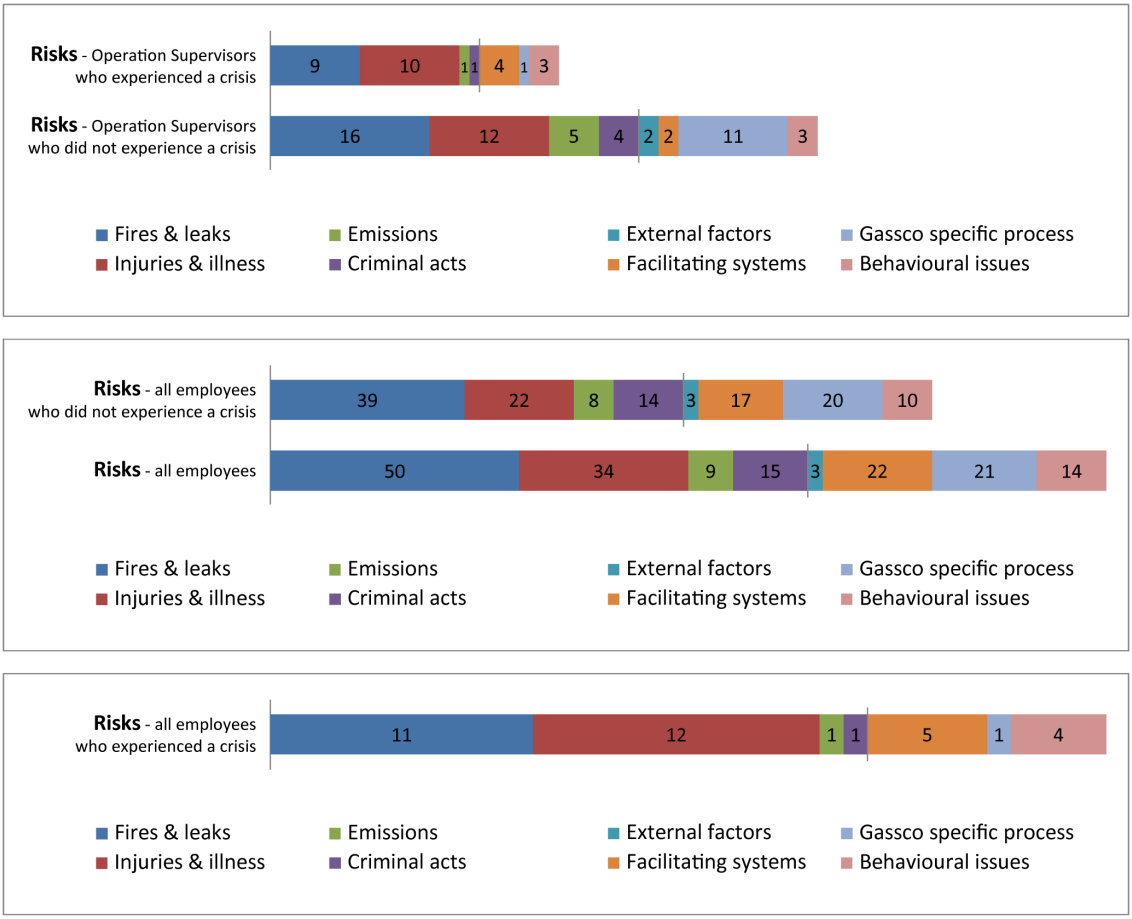

Figure 5-1 Differences in risk perception between employees who experienced a crisis situation and those who did not

We see that those who experienced a crisis situation are sensitive to 'Fires & leaks' as well as the other employees, but they are much more concerned about 'Injuries & illness', 'Behavioural issues', and problems with 'Facilitating systems'. There might be a twofold explanation for this. Firstly, due to their crisis experience they have some kind of knowledge on how systems might break down, quite often by wrong manipulation and how this has an impact on personal injuries (4 out of 6 interviewees who witnessed a severe crisis situation at a previous job attributed these incidents to behavioural issues when dealing with systems that eventually lead to personal injuries). Secondly, it might be argued that these persons have a fairly good knowledge of the company's procedures. As earlier indicated, these procedures predominantly focus on how to prevent systems' failures and personal injuries, and thus give clear guidelines on safety behaviour.

Comparing the constructs that were offered by all the interviewees and those who experienced a crisis situation, the differences are less explicit. As Figure 5-2 indicates, the employees who experienced a life-threatening crisis situation predominantly talk about 'Human factors' and 'Plant & process related issues', and less about 'Tangible & non-tangible damage' and 'Organisational relation structures'.

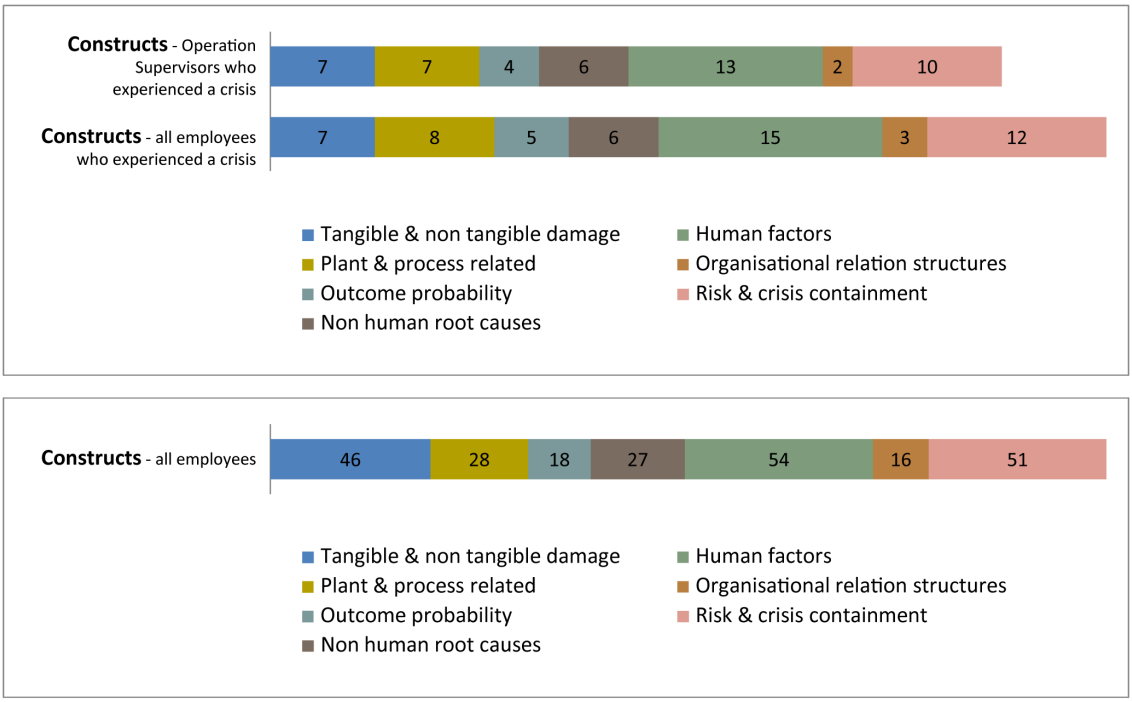

Figure 5-2 Differences in constructs between employees who experienced a crisis situation and those who did not

This indicates that the employees who experienced a life-threatening crisis situation at a previous job have a different view of the actual risks in the organisation. Furthermore, these employees also acknowledge the importance of crisis experiences in their attitude versus risk at work.

> *"That's the big disadvantage here; we don't face problems. Because nothing serious is happening here, no one has a sound knowledge of all the possible dangers on this plant. You do learn from your mistakes. But here, we don't learn anything at all." (Interviewee #26)*

There is evidence in the field of fire-fighters' trainings that by increasing the reality level of the exercises, for instance by experiencing a real 'flashover' (this is when the majority of an exposed surface in a space is heated to its auto-ignition temperature and emits flammable gases. Flashovers normally occur at 500 °C) in a simulator, fire-fighters' practical knowledge and risk awareness will increase massively (Daniels, 2006; Baumann et al., 2011). Therefore it could be argued that heuristics of real life-threatening situations do indeed have an impact on employees' risk perception.

5.2.3 Different kind of communication

To answer the question whether communication is the best tool to influence risk perceptions and encourage staff to be aware of safety and potential risks, we have to go back to the 'research method and design' section and the findings of the research. We know that the ZPT management team spends a lot of effort to disseminate the risk-alerting matrix among the staff. Safety meetings are regularly organised, and post-incident briefing sessions are part of daily routines (Gassco, 2009). But still, the data as presented in the findings, indicates that: 1) basically every individual in this organisation has his or her personal list of risks with high consequences, and 2) within each of the four 'work groups' at ZPT there is a high level of homogeneousness concerning the risk perceptions (in group), while the focus of risk perceptions within each group significantly differs.

Concluding that communication has no effect at all on the individual risk perceptions is a bridge too far. Of course, all the ZPT-staff mentioned different risks, but the dominant risk was still in the domain of 'Gas & leaks', which is no surprise as this is directly linked to ZPT's core business. However, it might be argued that the kind of communication that is used is not the most appropriate. Given the high degree of discrepancy between what the interviewees say and what ZPT disseminates, the question could be raised whether this organisation's safety communication is merely based on distributing procedures and guidelines rather than engaging staff in a safety dialogue. In the high reliability theory (HRT), for instance, the focus is clearly on how organisations

can create mindful infrastructures that diminish or even postpone damage produced by unexpected events and impair reliable performance (Weick and Sutcliffe, 2007). This concept of mindful infrastructures is based on employees' behaviour and engagement in an organisation-wide safety debate. The five basic principles of HRT (early tracking of small failures, reluctance to oversimplification, remaining sensitive to operations, maintaining capabilities for resilience, and deference to expertise) are all rooted in an open dialogue on safety, where all staff can make sense of and give meaning to potential risks (Weick, 2005) and by doing so help the organisation to avoid failures.

Therefore it could be argued that the more traditional the form of communication, i.e. the mere top-down transfer of risk information through procedures and guidelines, is not the most beneficial. To enforce risk perceptions among employees, with the aim of creating a safer work environment and protect the organisation against potential perils, it would be better to focus on an organisation-wide dialogue instead of relying on traditional communication tools.

5.3 Contribution

This research offers two significant contributions to theoretical knowledge. Firstly, it supports the concept of 'equifinal meanings' (Donnellon et al., 1986). My research indicates how all employees in one organisation have different interpretations of risks, but behave in ways that result in the desired safety record. Donnellon and her colleagues' research design was based on discourse analysis of the interpretation of a single message and the respondents' reported intention for action. Moreover, their study was based on students who acted as organisational members in a class setting. Therefore it might be argued that these findings were not generalizable beyond the student sample. According to Web of Knowledge, Donnellon et al.'s paper was cited 107 times, but none of these papers empirically tested or confirmed the concept of 'equifinal meanings'. Furthermore, the concept of 'equifinal meanings' describes a phenomenon, but it gives no explanation *why* everyone in the organisation has

a different view while the outcome in behaviour is similar. My work indicates how every single individual in one organisation has a divergent perception of the actual risks, while the organisation itself operates in a safe way.

A second contribution concerns support for the high reliability theory that argues for deference to expertise. Many empirical studies (Covello et al., 1987; Covello, 1991; McCallum and Covello, 1989; Renn and Levine, 1991; Peters et al., 1997; Terpstra et al., 2009) indicate a fundamental divide between the perception of risk among lay people, on the one hand, and the way in which risk experts present risk information, on the other hand. These initial studies explored the role of the psychological decision processes at play in improving societal risk taking (Slovic et al., 2000). The Psychometric Model, a theoretical framework that aims to measure risk perception with traditional attitude questions and non-traditional word association and scenario generation methods (Slovic, 2000) is still the dominant model to quantitatively analyse similarities and differences between lay and expert evaluations of risks (Slovic et al, 2002). However, this has not been tested in a tightly coupled and complex interactive organisation yet. My research findings, however, indicate that management (which might be seen as 'the experts' as this is the only team that has two engineers) indeed has a different perception of the present risks, but not one that is as broad as those of the operation supervisors. Hence, it supports an earlier remark linked to HRT (Weick and Sutcliffe, 2007) that expertise is situated on various levels in the organisation and not exclusively among 'experts'.

5.4 Recommendations for practice

Based on the findings of this empirical research, it might be argued that the management team of ZPT undervalues the rich knowledge concerning risk that already exists in the organisation. By focusing on the 'official' risk domains, and by labelling them in four broad categories (Fires & leaks, Injuries & illness, Emissions, and Criminal acts), Gassco neglects a whole range of risks that are known among ZPT-staff. The possibility of acting that way, by neglecting these risks (25 element groups in total!), is that the employees will slowly but steadily

lose this knowledge and eventually might not pay attention to signals that warn them for certain risks. According to Weick, people fail “because they remember the name but not the substance of the originating experience. This means that whenever events occur that are beyond the reach of the labels that people do share, they will be the last to know about those events” (Weick, 2005: 401). Weick refers to past incidents at NASA due to a disconnection between the labels that were placed on certain risks, and the wrong interpretation and comprehension of those labels. In other words, neglecting employees’ risk perceptions might move them further away from their own impressions and experiences regarding actual risks in their organisation.

Secondly, it is recommended to bring more expertise to the risk analysis process. The group of operation supervisors at ZPT has a more diverse view on the existing risks than any other group in the organisation. However, they were never consulted when the management team discussed the risk-alerting matrix (Gassco, 2009). In their seminal work on High Reliability Organisations, Weick and Sutcliffe (2007) advocate to be “sensitive to operations [as they] are attentive to the front line, where the real work gets done” (Weick and Sutcliffe, 2007; p. 12). They also argue to give deference to expertise, as “decisions are made on the front line, and authority migrates to people with the most expertise, regardless of their rank” (Weick and Sutcliffe, 2007; p. 16). Therefore, it would be recommendable to ZPT’s management team to bring in the operation supervisory team’s knowledge and experience on preparing, designing and testing a revised risk-alerting matrix.

Thirdly, it would be recommendable to promote attitudes of ‘healthy distrust’ in this organisation. In line with earlier findings in a similar organisation (Conchie and Donald, 2006), it could be argued that a system of checking and scepticism concerning actions among operation supervisors might be beneficial for a safer work environment. This type of ‘healthy distrust’ can also be found among air traffic controllers, and has proven to be pivotal for safe operations (Helmreich et al., 1999).

Finally, the impact of life-threatening crisis experiences on risk perceptions might advocate a different approach for crisis simulation exercises. Actual crisis exercises at ZPT take place only once a year, and are finished after two to three hours. Previous to the simulated crisis exercise, the operation supervisors' team gets a half-day briefing about the scenario, the aim of the exercise and its pitfalls. This in no way resembles real incidents. But the general assumption is that 'doing is learning', and by going through a certain crisis scenario it helps the participants to prepare for the worst. However, the interviewees who experienced a real crisis situation explicitly indicated the difference between a simulated crisis and a real one:

> *"Crisis exercises are fine, however, the reality is completely different. It's so weird to see people react without applying what they learned in a training." (Interviewee #13)*

Therefore it would be highly recommended to review the current crisis trainings and exercises, and turn them into more realistic experiences that help to increase risk and crisis awareness among all employees. Unannounced exercises, field trainings, and combined trainings with security services and first responders that last for at least 12 hours might be some areas for further improvement.

5.5 Limitations

Although this research, based on all the ZPT-staff's individual risk perception, offers various findings and recommendations for further development, one has to take into account that it only reflects the current risk perceptions among ZPT staff. Depending on future events, be they in the company or on an individual level, these research findings might vary. Moreover, this research was focused on individual perceptions of risk, to evaluate perceptions and attitudes of individuals within an organisation (Harvey et al., 2002). However, by doing so, plausible collective perceptions were deliberately neglected.

Another way to approach this research could have been by looking at the data in aggregate form and group individuals according to their similarities. However, as no two individuals in this company mentioned identical risk elements nor the same constructs, I decided to analyse and interpret the data in terms of 'work groups' rather than just the individuals.

This study was based on one single receiving terminal of Gassco: ZPT. Therefore, it might be argued that these findings are not generalizable beyond this single terminal, nor to the wider gas transport industry, nor to other tightly coupled and complex interactive organisations. However, I would suggest that there are aspects of what I have found which could sensitise other tightly coupled and complex interactive organisations in similar situations to the kinds of things that are important, such as giving deference to expertise, intensifying trainings, and valuing knowledge concerning risk that already exists in the organisation.

5.6 Recommendations for further research

This research indicates how different people in one organisation perceive various risks differently. By doing so, I have offered new insights to the concept of 'equifinal meanings', as described by Donnellon and her colleagues (1986), and supported a key insight of the HRO theory (Weick and Sutcliffe, 2007) concerning the deference to expertise at various levels in the organisation. Linking back to the literature on information processing systems (Dillon and Tinsley, 2008) the answer to the question *why* individuals' view on risks differ, might be found in the way people process information in their System 1 and 2 (Kahneman, 2011), based on biases and heuristics. However, answering the why question was not the aim of this research.

Although we know that everyone in an organisation has a divergent view on risks, we do not have an answer to the question *why* the outcome in collective behaviour is similar either? In other words, how do individuals with various perceptions on organisational risks collectively achieve coordination of safety attitudes? Donnellon et al. (1986) did not answer this question as they just

described the phenomenon, but not the underlying process. In this organisation, which was the subject of this research, like in many other organisations managing high-risk processes, the management team aims to create and sustain safety by standardising processes, procedures and guidelines, and supervision. According to Gosling and Mintzberg, the dominant view on management is Cartesian, in which “action results from deliberate strategies, carefully planned, that unfold as systematically managed sequences of decisions” (Gosling and Mintzberg, 2003, p. 61). My research actually suggests that this coordination of safety management is created more through shared norms, values, and beliefs, which is at complete odds with the dominant view on organisational coordination. Moreover, the fact that similar findings come out of similar groups seems to indicate some collective effects.

Therefore, the next research project (Part IV of this doctoral thesis) explores how these organisational members, while individually holding divergent perceptions on organisational risks, collectively achieve a coordination of safety.

PART IV: PROJECT 3 – EMPIRICAL RESEARCH

ABSTRACT

The dissemination of safety procedures and guidelines is perceived as pivotal to keep organisations managing high-risk technologies incident free. The role of clear communication is seen as essential in transferring these procedures and guidelines. However, the previous empirical research project in a gas-receiving terminal indicates how every single individual in that organisation holds divergent perceptions of the present risks. This suggests that transmitting information through various forms of communication fails to create a uniform perceived interpretation of the potential risks in an organisation. Hence, these variable risk perceptions might actually endanger safe operations.

On the other hand, the gas terminal that was the subject of this empirical research has been operating accident-free for more than twenty years. This is at odds with the average number of fatal accident rates in onshore gas companies. Therefore it might be argued that this gas-receiving terminal achieves some form of coordinated safety behaviour, based on a differing way of relating within the organisation. In an attempt to uncover these safety attitudes, this research project explores the interactive processes between all staff. Based on Social Network Analysis and qualitative interviews it indicates how the ongoing conversations about safety and risk avoidant behaviour constitute a safety culture in this gas-receiving terminal. Furthermore, it adds fundamental new insights to the existing knowledge in the field of 'communication constitutes organisation' research (CCO), and more specifically to the use of CCO in organisations managing high-risk technologies. Finally, recommendations for practice and viable directions for further research have been indicated.

1 INTRODUCTION

1.1 Individuals perceive risks differently

The premise for my previous research project (see Part III) was that communication by the top management team creates risk awareness and safety behaviour in an organisation managing high-risk technologies. By communicating standard operating procedures, guidelines, and standardised processes, a management team aims to supervise behaviour. One of the main findings of that research is that despite the clear communication of potential risks and required risk aversive measures, each individual in that specific gas-receiving terminal has a divergent perception of the present risks in their organisation. No two individuals in that organisation share exactly the same risk perceptions. There might be two interpretations for this finding. The first, a rather negative one, is that this gas receiving terminal is a very dangerous place to be as all the employees (including management) have divergent interpretations of the potential risks linked to their operations. A second, more balanced one, is that the combination of various risk perceptions is exactly what makes this plant a safer place to be, as the reasoning goes that two or more individuals when working together see more potential danger than one individual. Still, it also indicates that the communication of safety procedures and guidelines apparently does not result in consistent risk perceptions among all employees.

Before jumping to preliminary conclusions concerning the safety level of this gas-receiving terminal, we have to take into account that this plant has never faced a crisis situation over the last 20 years. It might be argued that one can be lucky for a couple of years, but maintaining incident-free operations for over 20 years is not a question of luck. It indicates some kind of well-coordinated safe operations.

Therefore, the question for this research is: how do people in an organisation managing high-risk processes maintain safe operations?

1.2 Mutual adjustment

Thus, the question that could be raised is how these safe operations are achieved? If it is not the communication of procedures and guidelines that shapes consistent risk perceptions, what is it that keeps this organisation safe? This question implies a form of collective behaviour and awareness regarding risks and risk aversive behaviour, rather than an individual appreciation of potential risks.

According to Mintzberg (1993), collective behaviour can be achieved through five coordinating mechanisms in organisations:

1. Mutual adjustment,
2. Direct supervision,
3. Standardisation of work processes,
4. Standardisation of outputs,
5. Standardisation of input skills.

This list seems a bit odd as three coordinating mechanisms are based on standardisations and one key component is about one person giving orders or instructions to several others, while the mutual adjustment mechanism is about achieving coordination through the simple process of informal communication. The latter is almost contradictory to the direct supervision mechanisms as an informal communication between two or more employees is intrinsically not verifiable behaviour that can be adjusted by direct supervision. Mintzberg argues that it has nothing to do with control, but is “merely an indication of the need to maintain a small face-to-face work group to encourage mutual adjustment when the work is complex and interdependent” (Mintzberg, 1993; p. 69).

According to Denyer and his colleagues, ‘mutual adjustment’ is achieved when two or more parties talk in real time and by doing so change the situation through communication (Denyer et al., 2011). In that perspective communication has to be seen as an interactive process that adjusts organisational behaviour, rather than a top-down tool for transferring guidelines

and standardised procedures. In other words, we have to make a distinction between communication as “instances of talk and message exchange that happen in certain contexts” (Koschmann, 2010; p. 432) and communication as a distinct mode of explanation (Deetz, 2009) for coordinated behaviour.

In an attempt to combine the views of Mintzberg (1993) and Denyer et al. (2011), it might be argued that in order to have a real time conversation in a complex work environment that changes the situation, the work process itself has to be designed in a way to ensure the required skills and knowledge to mutually adjust are present, as well as the structure in which this interactive coordinated process can happen. Although Mintzburg contends, “the work processes themselves […] can be designed to meet predetermined standards” (Mintzburg, 1993; p. 5), still, the act of adjusting work processes itself requires some sort of communication.

1.3 High Reliability Organisations as theoretical source

The theory of High Reliability Organisations (HRO) emerged in the 1980s when scholars from the Berkeley campus of the University of California (the so-called ‘Berkeley group’) studied how organisations operating with ‘high hazard’ technologies manage to remain accident-free for impressive lengths of time while meeting high production goals (Denyer et al., 2008; Shrivastava et al., 2009). HRO focuses on how organisations can create “mindful infrastructures that diminish or even postpone damage produced by unexpected events and impair reliable performance” (Weick and Sutcliffe, 2007; p. 2). Supporters of HRO argue that organisations can avoid failure by the early tracking of small failures, reluctance to oversimplification, remaining sensitive to operations, maintaining capabilities for resilience, and by deference to expertise. High-reliability theorists emphasise the human errors school of thought (Reason, 1997), which suggest that failures can be attributed to people.

For this research, the work on high reliability organisations (Weick and Sutcliffe, 2007) has been taken as the main theoretical source. HROs rely on five basic principles, whereas the first three have to do with anticipation (preoccupation

with failure, reluctance to simplify, and sensitivity to operations), while the latter two look at containment (commitment to resilience, and deference to expertise). The principles of anticipation “focus on the prevention of disruptive unexpected events” (Weick and Sutcliffe, 2007; p. 64). It is all about capturing early signals of unexpected or unwanted events, having the right diagnosis of these signals, and transforming that diagnosis into meaningful actions in a specific context. In other words, anticipation aims to prevent an organisation from unwanted events. The two principles of containment on the other hand “aim to prevent unwanted outcomes *after* an unexpected event has occurred rather than to prevent the unexpected event itself” (Weick and Sutcliffe, 2007; p. 65). It helps HROs to react in a way that reduces unwanted outcomes after an unexpected event occurred. In that perspective, resilience is all about “large and varied response repertoires, competence in reassembling existing practices into new combinations, intense sharing of information, and a well-developed ability to maintain emotional control in the face of chaos” (Weick and Sutcliffe, 2007; p. 81). Responding to unexpected events also requires decision making that is based on expertise rather than organisational ranks. Therefore, Weick and Sutcliffe recommend decoupling authority and expertise, as the latter “resides as much in relationships as in individuals, meaning that interrelationships, interactions, conversations, and networks embody it” (Weick and Sutcliffe, 2007; p. 82).

However, simply applying the various principles that support these two dimensions are no guarantee for high reliable operations. According to Weick and Sutcliffe (2007) there is an overarching prerequisite for achieving high reliable organising, which is ‘mindful organising’. Mindful organising supports a different mindset about the things that can bring an organisation into jeopardy. It is about a set of attitudes and conceptions, such as “human alertness, experience, skill, deference, communication, paradoxical action, boldness, and caution” (Weick et al., 1999; p. 102) that aim to foresee the unforeseeable. In an attempt to do so, Weick and Sutcliffe’s advice is to reinvent the wheel every chance you get, as “you’re a slightly different person from the last time you reinvented the wheel” (Weick and Sutcliffe, 2007; p. 149). This attitude of

mindful organising encourages organisational members to detect flaws or minor mistakes that they may have missed before, and by doing so it prevents an organisation from unwanted events. Hence, it describes a corporate culture in which safety values and expectations about risk aversive behaviour and early (mindful) detections of flaws is encouraged. In an attempt to install and maintain this corporate culture, Weick and Sutcliffe denote five elements that have to be put in place as a prerequisite for producing a culture of mindful organising. These elements are: thinking differently about 1) success, 2) simplification, 3) strategy, 4) plans, and 5) authority (Weick and Sutcliffe, 2007; p. 148).

Following from these theoretical conjectures, I will examine how safety behaviour is achieved in a high reliability organisation, whether the work process or its structure is designed in a specific way, and the distinct role of mutual adjustment in this context. In the next chapter I will explore some of the literature that focuses on the communicative role in this adjusting work process.

2 REVIEW OF THE LITERATURE

2.1 Introduction

As indicated in the previous chapter, the question could be raised whether it is the communicative transfer of risk information that is keeping an organisation safe, or something else that has little to do with this type of safety communication. The aforementioned form of an informational view of communication is rooted in a view of communication that expresses organisational realities (Ashcraft et al., 2009), one that perceives communication as a mere tool to support management practices in organisations. Axley (1984) describes this type of communication as a transmission model, a linear transmission process from sender to receiver and from receiver to sender in a cycle of message production, transfer, and reception. In this view communication does not create reality, it is a question of transferring information of already formed realities to one another (Ashcraft et al., 2009).

Although scholars have approached organisations as social phenomena using language, interactions, symbols and sensemaking (Putnam and Nicotera, 2009), and thus a phenomenon in which communication is crucial for organising, the research on how communication generates organisational realities (Ashcraft et al., 2009) is a more recent endeavour (Putnam and Nicotera, 2009). In the last decade, multiple scholars (for an overview see Blaschke et al., 2012; p. 880-881) aim to address “how complex communication processes constitute both organising and organisation and how these processes and outcomes reflexively shape communication” (Putnam and Nicotera, 2010; p. 159).

This divide between a transmission view and a constitutive view of communication is rooted in the distinctive attributed roles of communication in the ontology of an organisation. On the one hand, the constitutive view perceives ‘organisation-as-verb’ (process/doing), while the transmission view distinguishes ‘organisation-as-noun’ (entity/being) (Putnam and Nicotera, 2010;

p. 159). This divide between verb and noun, between process and entity, is linked to the ontological perspective of organisations, where the latter has a realistic perspective and the former an interpretivist view of organisations.

As the process view focuses on how organisations are doing things and how it "creates elements and communicative processes that produce organising and organisation" (Putnam and Nicotera, 2010; p. 160), I will approach my topic of maintaining safe operations from a process ontological point of view, more specifically in the following two domains: 1) the way it looks at organisation-as-verb, and 2) the way it looks at communication-as-verb.

Therefore, over the next sections I will summarise some of the main perspectives in the existing literature on Process Organisation Studies, and the concept of Communication Constitutes Organisations, and link each to the aforementioned domains.

2.2 Process ontology and organisations

Process Organisation Studies are rooted in an interpretivist thinking of organising and organisations as being in flux, in a continual process of becoming, where organisations are viewed as processes "in the making" (Hernes, 2007). In other words, Process Organisation Studies are exploring evolving phenomena in organisations, rooted in an array of processes and not in abstract structures (Putnam et al., 2010). It does not deny the existence of events or states, but it insists on how activities and interactions in an event contribute to the constitution of further processes. Therefore, Process Organisation Studies prefer to focus on inter-actions to analyse self-standing actions (Langley and Tsoukas, 2010).

These Process Organisation Studies are in contrast with the substance view of organising and organisations, whereas organisations are perceived as "things made" (Hernes, 2007). This division into two non-overlapping visions, (substance versus process) might be best summarised as follows:

- The substance view: an organisation exists by the grace of structures, guidelines, and basic functions, and although it implements processes these do not change the substance of the organisation,
- The process view: an organisation is created by people and thus the unique product of interpretations, consultations, and the interaction process among its members.

Both views are in line with Putnam and Nicotera's (2010) interpretation of 'organisation-as-verb' (process view), and 'organisation-as-noun' (substance view). This dichotomy between substance and process is also reflected in the literature on organisational communication, whereas the substance view perceives communication as "the flow of information from one person to another" (Dainton and Zelly, 2011; p. 2), the process view defines communication as "the process by which people interactively create, sustain, and manage meaning" (Conrad and Poole, 1998; p. iv).

2.3 Process ontology and communication

In the field of Process Organisation Studies there is an emphasis on "narrative forms of knowing" which incorporates linkages between experienced events over time and gives meaning to particular new organisational events (Langley and Tsoukas, 2010). This notion of incorporating linkages and giving meaning is achieved when two or more people's interactions involve existing metaphors-in-use (Axley, 1984) to set up organisation-wide dialogues on new and future events. By doing so, they create, sustain and manage meaning (Conrad and Poole, 1998) through some kind of mutual adjustment (Mintzberg, 1993).

This communicative approach in Process Organisation Studies focuses on how 'communication constitutes organisations' or 'CCO' (for an overview on the CCO perspective in organisation studies, see: Blaschke et al, 2012). CCO draws on the view of organisations as "networks of conversations" (Ford, 1999; p. 485), where through "telephone calls, meetings, planning sessions, sales talks, and corridor conversations […] people inform, amuse, update, gossip, review, reassess, reason, instruct, revise, argue, debate, contest, and actually

constitute the moments, myths and, through time, the very structuring of the organization" (Boden, 1994, p.6). In other words, communication is perceived as central to the social construction of the organisation's reality (Hübner, 2007) as it takes an active stance in that mutual interactive process.

CCO differs from the 'informational view of communication', the focus is on expression and the process is a straightforward transfer of information (Koschmann, 2013). It perceives organisations "as" communication, opposed to communication that happens "within" organisations. Instead of viewing communication as merely the transfer of information, this approach sees communication as the fundamental process that shapes our social reality, a rather complex process of continually creating and negotiating the meanings and interpretations that shape our lives (Koschmann, 2012). Therefore, this approach is more a 'constitutive view of communication' as it creates our social world.

This constitutive view of communication might provide an answer to how organisational members obtain collective coordinated behaviour. Although getting the right information to everyone in a high-risk organisation is absolutely critical, it still does not mean that all those people interpret that information in the same way. Therefore, studying the informative communication process in an organisation, such as transmitting data between senders and receivers, merely discloses part of a complex mutual interactive process of creating, sustaining, and managing meaning (Conrad and Poole, 1998) among organisational members.

To conclude, based on the interpretation of the literature, it might be argued that through mutual adjustment, organisational members create and transform their organisation in order to solve exceptions and problems, and through these communicative, and thus social, interactions they obtain coordinated behaviour

Following from this my research sets out to examine how maintaining safe operations is achieved in an organisation managing high-risk processes, and the distinct role of mutual adjustments in this context.

3 RESEARCH METHOD AND DESIGN

In the previous chapter I indicated the theoretical rationale for gaining more insights how communication constitutes organisations. In this section I will explain the research methodology and the design I used for uncovering how CCO is represented in an organisation managing high risks. The findings of this empirical research will be discussed in chapter 4 of this Part IV.

3.1 Introduction

According to many scholars who have adopted the CCO perspective, organisations are networks of communication episodes, conversations, or texts (Blaschke et al., 2012). To uncover these networks, the research has to be designed in a way that uncovers how these interactions play in an organisation, who interacts with whom, and how it unfolds. One potentially suitable method for uncovering these collective interactive processes in a particular organisation is social network analysis (SNA). A 'social network' refers to "the set of actors and the ties among them" (Wasserman and Faust, 1994; p. 9). The theoretical basis for SNA lies in the social cognitive view on organisations, whereas "organisations and environments are reconceptualised as cognitions in the minds of participants" (Ibarra et al., 2005; p. 365). In other words, organisations are perceived as complex relational systems where individuals' positions within that network may affect both perceptions and their sensemaking of nodes and relationships (Ibarra et al., 2005). These ties or relationships among various actors depict the structure of a group. The analysis of such a structure might uncover "the functioning of the group and/or the influence of this structure on individuals within the group" (Wasserman and Faust, 1994; p. 9).

In an attempt to describe SNA, Kadushin used the metaphor of a traffic helicopter: "It is like being stuck in a traffic jam surrounded by cars and trucks. The traffic helicopter can see beyond our immediate surroundings and suggest routes that might extricate us […] It allows us to see beyond our immediate circle" (Kadushin, 2012; p. 4).

According to Wasserman and Faust (1994) SNA is not only about dyads, triads, or subgroups, it is also about “the ability to model the relationships among systems of actors” (Wasserman and Faust, 1994; p. 19). Whereas a system has to be seen as the ties among members of some group, and a group as “a finite set of actors who for conceptual, theoretical, or empirical reasons are treated as a finite set of individuals on which network measurements are made” (Wasserman and Faust, 1994; p. 19). Although SNA seeks to understand the relationships and dynamics between individuals in organisations, it is essential to bring in the role of individuals in social network analysis as they “account for micro-foundations of structural research” (Kilduff and Krackhardt, 1994; p. 88). By doing so, I avoid looking at organisations as the sum of its individual parts, but look more at the interrelating intensions and perceptions that lead to collectively maintaining safe operations.

Therefore, the questions in the research process aim for the relations between individuals, and the individual and collective perceptions. The result will be more than collective constructs on risk and safety perceptions, but rather how people in an organisation interrelate with regard to safety and risk awareness. The objective is to identify the patterns of interrelating and collective mindful organising (Weick and Roberts, 1993; Weick and Sutcliffe, 2007) and by doing so bring the questions to an individual level, to see how they actually have an effect on safety attitudes. The questions that will be asked focus partly on the social networks on the one hand, and at what they do and how they contribute to mindful organising on the other hand.

3.2 Subject of research

The Belgian receiving gas terminal of Norwegian gas transport company Gassco AS was selected for this research. It was also the unit of analysis in my previous empirical research project (P2). Therefore, I will briefly describe the characteristics of this Belgian Gassco branch. More details on organisational structures, production process, etc., can be found in the previous section of this doctoral thesis (see Part III, pages 181-183). Gassco AS is a Norwegian state-

owned gas transport company with headquarters and a central operation control room in Bygnes (Norway). Gassco has four EU receiving terminals in Germany (Dornum and Emden), Belgium (Zeebrugge), and France (Dunkirk), and two UK receiving terminals in St. Fergus, and Easington. In total, Gassco AS employs 353 staff. The Belgian receiving terminal, which is located in the port of Zeebrugge, handles the total volume of gas that is transported through a 40" pipe (the so-called 'Zeepipe'), with a flow rate of 42 million Nm^3 per day[11]. This terminal remotely controls Gassco's French receiving terminal in Dunkirk, which is responsible for all the Norwegian gas that arrives through the so-called 'Franpipe' (42" pipe), with a flow rate of 54 million Nm^3 per day. The Belgian and French receiving gas terminals jointly handle 26% of the Norwegian gas export (Norwegian Ministry of Petroleum and Energy and Norwegian Petroleum Directorate, 2012). All staff of Gassco's receiving terminal in Zeebrugge, referred to as 'Zeepipe Terminal' or 'ZPT', are the subject of my research.

Since 2008, I have worked as a consultant for ZPT in the field of risk and crisis management. My company contributed to their emergency plans (both for Belgium and France), and we have run multiple safety trainings and crisis exercises. These experiences offer me a good view of the organisation's safety culture, strengths and weaknesses, which according to Roberts and Rousseau (1989) is a prerequisite for conducting research in organisations managing high risk processes. "Frequent and often long-term interactions among researchers, designers, operators, and managers are important if any real understanding of high-reliability organizations is to be obtained […] A well specified research project can emerge only after the researcher has sufficient training in the ways of the organization" (Roberts and Rousseau, 1989; p. 134).

3.3 Sample

The total number of staff at the Belgian receiving terminal of Gassco in Zeebrugge (ZPT) is 30; 4 women and 26 men. This is one full time staff

[11] Nm^3 stands for 'Normal cubic meter' and is a common unit used in the industry to refer to gas emissions exchange. It always depends on the individual circumstances of each gas, pressure, and use.

member extra compared to early 2012 (when the previous research, as described in Part III of this document, was executed). Between 31 January 2013 and 13 March 2013, 28 individual interviews were held at the premises of ZPT. Two staff members were not included in the interviews as they were on long-term sick leave. All face-to-face interviews were executed in Dutch, the employees' native language. Each individual interview took approximately 20 minutes and was digitally recorded. Every interview was attended by Eline Claerhout, a master-after-master student in Organisational Communication at the University of Leuven (Belgium). Eline was doing an internship at my company. She took notes, observed the interviewees, and took part in the internal discussions concerning the interpretation of the data.

The table below (Table 3-1) gives an overview of the basic characteristics of the interviewees as on 31 March 2013.

Division	**n (men)**	**n (women)**	**Age (mean)**	**Years with Gassco (mean)**
Management:	4	0	45.50	16.25
Administration:	2	2	41.00	13.00
Operation Supervisors:	15	0	41.86	13.03
Maintenance:	5	0	50.40	16.00

Table 3-1 Overview of interviewees at ZPT

3.4 Research design

According to Blaschke and his colleagues (2012), the range of methodologies to analyse the relationship between communication and organisation is rather limited. Although the CCO perspective has been well theorised over the last two decades, it still faces methodological challenges in the empirical study of these processes (Putnam and Nicotera, 2010).

Based on a review of the CCO literature, Blaschke, Schoeneborn and Seidl (2012) extracted three main requirements that need to be met to research "the

connectivity between interactions that constitute organisations as ongoing processes of communication" (Blaschke et al., 2012; p. 884):

1. the constitutive character of communication is fundamental to CCO thinking, therefore network analysis is suitable for the CCO perspective only if it treats communication as constitutive of organisation,
2. communication processes cannot be completely and intentionally determined by individual actors, therefore network analysis needs to account for the emergent and not fully determinable character of communication and thus of organisation,
3. to underline the fundamentally processual character of communication, organisations have to ensure that they perpetuate their communication, if they are not to disappear altogether. In other words, every communication event calls forth and is linked to further communication events, which form and reform the organisation over time.

These arguments substantiate my decision to use network analysis to examine the communicative processes that constitute safe operations at ZPT.

Besides the data I acquired through social network analysis, I made use of three other sets of data to analyse the underlying processes:

- qualitative data from the semi-structured interviews during the SNA-process and in six interviews that were executed after the analysis of the SNA-data. This allowed me to place the indicated links between the interviewee and his or her colleague in a broader context,
- ethnographical data from attending management and safety meetings, in order to examine the coordinated behaviour in action,
- archival data from brochures, DVDs, and ZPT's internal documents, in order to have a broader understanding of the past courses and trainings, and to understand the roots of some current procedures and guidelines.

3.4.1 Questionnaire

As explained in the first chapter of this part of the doctoral thesis (see: Part IV, "1.3 High Reliability Organisations as theoretical source"), the work on high

reliability organisations (Weick and Sutcliffe, 2007) was used as the main theoretical source for this research project. Therefore, the questionnaire that was used for the network analysis was based on the five principles of high reliability organisations as described by Weick and Sutcliffe (2007), supplemented by questions based on findings from my previous empirical research projects (P1 and P2). This questionnaire, as presented in table 3.2, has been submitted and approved by the supervisory panel prior to the interviews at ZPT.

#Q	Question	Rationale	Reference
1	Who would you be willing to report a mistake to? Who would report a mistake to you? *A. What is the nature of their relationship with you?*	HRO Principle 1: Preoccupation with failure	Weick & Sutcliffe, 2007; p. 9-10
2	Who more clearly articulates the dangers/risks in this organisation? *A. How do they do that?*	HRO Principle 2: Reluctance to simplify	Weick & Sutcliffe, 2007; p. 10-12
3	Who in a hierarchical position spends time with individuals down in operations?	HRO Principle 3: Sensitivity to operations	Weick & Sutcliffe, 2007; p. 12-14
4	Who in this organisation works hardest to maintain normal operations? *A. How do they do that?*	HRO Principle 4: Commitment to resilience	Weick & Sutcliffe, 2007; p. 14-15
5	Who would you turn to for support if faced with a work problem? Who would turn to you for support when facing a work problem *A. Why?*	HRO Principle 5: Deference to expertise	Weick & Sutcliffe, 2007; p. 15-17
6	Who would you turn to for a personal problem? Who don't you go to? *A. Why?*	Probing for trust in the relationships	P2.
7	Who do you talk to about safety generally? Who don't you talk to about safety? *A. Why?* *B. Are there particular groupings in this organisation?* *C. Which ones?*	Probing for shared values and norms concerning safety in the same group	P2.
8	Who shares the same safety attitudes/behaviour in this organisation? *A. What are these attitudes?* *B. Are there different attitudes for different groupings?*	Probing for equifinal meanings concerning safety	P2 + Donnellon et al., 1986
9	In the case of a crisis situation, who	Probing for expertise in	P2 + Daniels, 2006;

	has the experience to take the actions that need to be taken?	real-life crisis situations	Baumann et al., 2011
10	Who do you talk to when you have a safety issue or when you see an unsafe situation? Who talks to you when they have a safety issue or when they see an unsafe situation? *A. Does it vary with the nature of the situation?*	Probing for broad risk perceptions beyond the official risk matrix	P2 + Weick, 2005; p. 401
11	Who do you need to manage when it comes to execute safe operations at work? Who would manage you when it comes to execute safe operations at work? *A. Why?* *B. What is their formal / informal relationship to you?*	Probing for "healthy distrust"	P2 + Conchie and Donald, 2006
12	Who do you socialise with outside of work?	Probing for trust in the relationships	P2.
13	Who listens to you when it comes to accepting orders concerning safety measures? Who do you listen to when it comes to accepting orders concerning safety measures? *A. Does it vary?* *B. Why?*	Probing for leadership through expertise	P1 + Weick & Sutcliffe, 2007

Table 3-2 Questionnaire for SNA interviews at ZPT

The additional questions, indicated in italic as "A", "B", or "C" have been treated as open-ended qualitative questions to achieve a better understanding of the relationships indicated by the interviewees and their attitude towards mindful organising.

3.4.2 Pilot

Prior to this SNA-research project at ZPT, pilot interviews were held with colleagues at my own company. These interviews took place on January 2013. The objective of this pilot was twofold: 1) a simple check whether the SNA-questions made sense and were well understood by the interviewees, and 2) to get a feel of the usefulness of answers on the quantitative questions. Based on the outcome of this pilot, one question was eliminated from the initial questionnaire (question number 8) and several questions were slightly adapted. Table 3.3 shows the updated questionnaire after the pilot interviews.

#Q	Question
1.1	Imagine you made a mistake (with little or no impact on the organisation), who would you report that mistake to?
1.2	Imagine someone made a mistake (with little or no impact on the organisation), who would report that mistake to you?
2	Who in this organisation is most likely to initiate discussions about safety and risks?
3	Who in the management team spends frequent time with staff on the shop floor?
4	Who in this organisation works hardest to maintain normal operations?
5.1	Who would you turn to when faced with a work problem?
5.2	Who would turn to you when faced with a work problem?
6.1	Who would you turn to for a personal problem?
6.2	Who don't you go to?
7.1	Who do you talk to about safety?
7.2	Who don't you talk to about safety?
9	In case of a crisis situation, who has the experience to take the actions that need to be taken?
10.1	Who do you inform when you have a safety issue or when you see an unsafe situation?
10.2	Who informs you when they have a safety issue or when they see an unsafe situation?
11.1	Who do you need to check when it comes to executing safe operations at work?
11.2	Who would check you when it comes to executing safe operations at work?
12	Who do you socialise with outside of work?
13.1	Who deserves your respect when it comes to safety measures?
13.2	Who does not deserve your respect when it comes to safety measures?

Table 3-3 Adapted questionnaire for SNA interviews after pilot

All of these questions were asked to each ZPT-employee, and all the data was captured and analysed. In the next chapter (see: "4 Findings") I will separately discuss both HRO dimensions (anticipation and containment), the elements of mindful organising, and the questions relating to trusted social relationships, based on the maps and tables that emerged from all the data analysis.

3.4.3 Additional interviews and observations

In a second wave, at the end of April 2013 and the beginning of May 2013, I interviewed 6 employees for a second time. These individual interviews were more a kind of triangulation process where I showed every participant the various maps and subsequently checked for their experiences and interpretation of the data. This approach is in line with O'Donoghue and Punch's interpretation of triangulation as a "method of cross-checking data from multiple sources to search for regularities in the research data" (O'Donoghue and Punch, 2003; p. 78). It was also a subtle approach to sense whether my initial

interpretation of the data was in line with their day-to-day experiences. The selection criteria for the six interviewees were based on the following rationale:

From the results of P2, I selected two groups: 1) the (6) employees who experienced a crisis situation in a previous workplace, and 2) the (8) employees who have worked less than 9 years at ZPT. I selected the latter group, as they did not participate in a Safe Behaviour Programme in Norway in 2004. In the introduction section of the following chapter ('4.1 Introduction') I will explain in detail the objectives and content of this Safe Behaviour Programme.

I then selected the most and the least dominant person from each group as represented in the various maps (2 with a crisis experience, and two with less than 9 years of work experience at ZPT). I then made sure I had various positions in this second round of interviews (maintenance, operation supervisors, and adjunct operation supervisors). Complementary to these four interviewees I interviewed the CEO and the HSEQ manager, with the same purpose: to check their interpretation of the data, and to sense whether my interpretation of the data was in line with their experiences.

Finally, I attended a Morning Safety Briefing and a Management Meeting at ZPT. The Morning Safety Briefing is partly a formal hand-over of the night shift operations to the day shift. On the other hand, all maintenance and operations staff, operations manager and safety manager review all operational issues, minor deficiencies, and other points of interest of the past 24 hours. The Management Meeting is a daily formal encounter of all members of the management team and the head of accounting. Every morning, it starts with a quote from Steven Covey's Inspiration Calendar, the CEO's personal reflection of this quote and his appeal to those present to reflect on company issues that relate to Covey's quote. They then systematically discuss various topics, divided over 10 themes (such as: ongoing works today, notifications, finance, inspections, etc.). Both meetings last about 45 minutes each.

3.4.4 Analysis of the results

The SNA data was analysed with UCINET 6, a software package designed for the analysis of social network data. Intermediate results were discussed with my supervisor and the panel chair (on 13 March 2013) to evaluate the appropriate method for analysis and the initial findings. These results will be offered in the next chapter (see: “4 Findings”).

The qualitative data, captured through the open-ended questions and in the second round of interviews with a number of individuals at ZPT, as well as the observation notes of the various meetings I attended, have been transcribed and then analysed with Dedoose-software. In that process, two distinct sets of codes were used: the elements for producing a culture of mindful organising as described by Weick and Sutcliffe (2007, p. 148), and a set of attitudes that aim to foresee the unforeseeable (Weick et al., 1999; p. 105-106). These elements and the results of the analysis will be explained and discussed in more detail in the next chapter (see: “4.7 Mindful organising”). It is worth mentioning that Dedoose-software was used in multiple publications (see for instance: Hay et al., 2008; Lieber et al., 2009; Lin et al., 2010; Tshuma et al., 2012), and was indicated in the Journal of Ethnographic and Qualitative Research as valuable for mixing qualitative and quantitative methods (Lieber, 2009).

3.4.5 Ethical approval

An ethical approval was asked and approved by the committee at Cranfield University, School of Management. Each interviewee was fully informed about the objectives of the research, their freedom of participation, and the confidential character of the interviews.

4 FINDINGS

In this chapter I will present the findings that came out of the Social Network Analysis at ZPT and the qualitative interviews and observations. Social networks connote complex sets of relationships between members of social systems, and in this research it indicates the extent to which different nodes (indicating ZPT employees) form ties with similar versus dissimilar others concerning HRO issues. More specifically, it indicates who is linked, in a formal or informal way, to whom when it comes to various safety related issues at ZPT. The ties between two or more actors indicate a link concerning a specific topic that was raised in a question. Sometimes these ties can be reciprocal (when two actors refer to each other), transitive (when A refers to B, B to C, and C to D, such as in an hierarchical situation for instance), or simply referable (when one actor is referring to one or more actors).

In the various maps presented in this chapter, the centrality of the nodes on the map refers to a group of metrics that aim to quantify the 'importance' or 'influence' of particular actors within the network. The more central, the more 'degree centrality', which is defined as the number of ties a node has. Also presented in the next sections are 'In Degree' and 'Out Degree-ties. 'In Degree' stands for the number of times a person is referred to by others, while the 'Out Degree' indicates the number of times one person refers to others. These in and out degrees will be presented in those cases where it might be insightful to have a clearer view on how many times a specific person points to his/her colleague, or is indicated by his/her colleagues.

In referring to my data in the next sections, the following abbreviations are used:

- ADM: member of the administration team
- AOS: member of the adjunct operations supervising team
- C: contractor (not specified, thus every none-Gassco employee)
- MNG: member of the management team
- MT: member of the maintenance team
- OS: member of the operations supervising team

The numbers behind the abbreviations indicate a person in that specific team. For confidentiality reasons, the names have been masked.

Throughout this chapter I have used italics for a specific purpose. This is to signify that interviewees have expressed quotes or words that I have italicised.

First of all, I will indicate how the various questions that were raised in the social network analysis were probing for more clarification concerning the two HRO dimensions (anticipation and containment) and trusted social relationships. I will then elaborate on how the elements of mindful organising were captured through the qualitative interviews and observations.

4.1 Structuring of the data

All ZPT employees were asked the 12 questions (as presented in Table 3-3 on page 242). The first five questions are all linked to the HRO principles (Weick and Sutcliffe, 2007), whereas the other seven questions are linked to findings and/or assumptions that were made in the previous research projects (P1 and P2). However, most of these findings or assumptions are linked to one of the five HRO principles as well. According to Weick and Sutcliffe (2007), the five HRO principles have to be broken down into principles that refer to anticipation of harmful events and principles that refer to containment of harmful events (see also: “1.3 High Reliability Organisations as theoretical source” on page 228).

Therefore, the various questions were attributed to the two dominant groups – anticipation and containment – and its findings will be discussed according to these two distinctions, not according to the individual principles. Two questions that probe for trusted social relationships (questions 6 and 12) relate to the findings of the previous research project (P2), and its findings will be discussed separately as well. An overview of the various questions, linked to the two dimensions of HRO and the social relationships are illustrated in the table below (Table 4-1).

Weick, K. E, Sutcliffe, K. (2007). *Managing the Unexpected – Resilient Performance in an Age of Uncertainty*, J Wiley & Sons, San Francisco, CA.					**P2**
Preoccupa-tion with failure	Reluctance to simplify	Sensitivity to operations	Commitment to resilience	Deference to expertise	Trusted social relationships
Questions relating to anticipation			*Questions relating to containment*		*Questions relating to P2*
Q1: Reporting a minor mistake Q2: Initiating discussions about safety and risks Q3: Spending time on the shop floor Q7: Talking to someone about safety [*also relating to P2*] Q10: Alerting safety issues or unsafe situations [*also relating to P2*] Q11: Focusing on the safe execution of operations [*also relating to P2*]			Q4: Working hard to maintain normal operations Q5: Turning to someone when facing a work related problem Q9: Taking actions in case of a crisis situation [*also relating to P2*] Q13: Deserving respect for taking safety measures [*also relating to P1*]		Q6: Turning to someone with a personal problem Q12: Socialise with someone outside of work

Table 4-1 Questions linking the two HRO dimensions and P2

Over the next sections I will separately discuss both HRO dimensions (anticipation and containment), and the questions relating to social relationships, based on the maps and tables that emerged from the social network analysis data. In an attempt to evaluate the elements of mindful organising at ZPT, I will discuss the collected qualitative data in a final separate section (see: “4.7 Mindful organising”). The qualitative data was collected on three occasions: 1) during the social network analysis: I raised various open-ended questions for more clarification concerning the interviewees’ answers, 2) multiple meetings (such as: Morning Safety Briefings, and a Management Meeting), and 3) after I finished all the social network analysis interviews, I went back to a number of interviewees (including two members of the management team) to probe their interpretation of the data and their appreciation of initial observations concerning the elements of mindful organising without, however, using the term ‘mindful organising’.

The interpretations of these findings and the link to the earlier presented literature will be discussed in the next chapters (see: “5. Interpretation of the findings” and “6. Discussion”). A full detailed overview of the metrical data for each of the questions can be found in Appendix H.

4.2 Introduction

It is essential to note that in 2004 all ZPT staff followed a 'Safety Behaviour Programme', organised by Statoil. In those days, the Zeepipe Terminal was part of Norwegian company Statoil, and it became part of Gassco in 2007. Multiple ZPT employees referred to this Safety Behaviour Programme as *"a mind blowing experience"* (OS2). According to the former company's brochure (Statoil, 2002), the intention was to embrace over 25,000 employees over more than 100 two-day workshops in Norway. The programme paid particular attention to five of what they call 'soft barriers' that play an important part in safety thinking. These are: correct prioritisation, compliance, open dialogue, continuous risk assessment, and caring about each other. All of these workshops were delivered by members of Statoil's top executive team, by the relatives of somebody killed during an anchor handling operation, and a presentation by a severely burned safety instructor who almost died when fighting a methanol fire. Although none of the presenters at these workshops were scholars in the field of high-reliability organising, the five aforementioned 'soft barriers' resemble a mixture of the HRO principles with Behaviour Based Safety (BBS) principles (for more insights on BBS, see for instance Geller, 2001; Roughton and Mercurio, 2002). It is known that in the first years of the 21st century, Statoil dabbled in BBS concepts and added a European/Norwegian flavour (Antonsen, 2009).

In the next chapter (see "5. Interpretation of the findings") I will link these 'soft barriers' and HRO principles back to the overall findings in an attempt to evaluate ZPT's current level of congruence, and to indicate the significance of these findings to the company's level of mindful organising.

4.3 Overall findings

Before diving into detailed findings and insights, I would like to provide a general picture of the findings upfront. This might help the reader to interpret each partial insight or finding in the broader context of this research.

The social network analysis uncovers the following broad insights:

- Everyone at ZPT talks to everyone about safety. These safety conversations are rooted in the safety procedures and guidelines, which in turn are the result as well of active conversations about how to improve safety related issues by refining existing procedures and guidelines.
- This collective safety attitude, which is inspired by Statoil's Safety Behaviour Programme, apparently extends to new employees. The various employees who joined ZPT after 2004, and thus never participated in Statoil's safety workshop, absorbed this 'safety walk the talk' as they are frequently indicated as initiators of conversations about safety.
- The management team has a specific steering role in the mindful organising processes. While they have been creating a mental space to have these type of conversations, the management team has a leading role in feeding, conducting and leading these conversations by example.

In the next sections, I will offer more details that support these insights.

4.4 Anticipation

In this section, the data retrieved from six questions of the social network interviews will be analysed and discussed. These questions are based on the first three HRO principles (questions 1, 2, and 3), as presented by Weick and Sutcliffe (2007), and three questions that relate to findings of the previous research project (questions 7, 10, and 11). All questions refer to the three anticipation principles, as presented by Weick and Sutcliffe (2007). They look at how employees are preoccupied with failure, their reluctance to simplify, and their sensitivity to operations. According to Weick and Sutcliffe, the principles of anticipation "focus on the prevention of disruptive unexpected events" (Weick and Sutcliffe, 2007; p. 64). It is all about capturing early signals of unexpected or unwanted events, having the right diagnosis of these signals, and transforming that diagnosis into meaningful actions in a specific context.

Therefore, the questions that were asked probed for this anticipatory attitude:

- Question 1 checked whether employees have an attitude to report minor mistakes, even if they do not harm operations. The rationale for raising this question was to gauge the employees' preoccupation with failure.
- Question 2 encouraged the interviewees to indicate people in the organisation that initiate discussions about safety issues and risk. The rationale for raising this question was to uncover the employees who show an attitude of reluctance for simplifying safety and risks.
- Question 3 aimed to identify those members of the management team who spend considerable time on the shop floor in an attempt to get a good feel of the issues and concerns that reside in the organisation. The rationale for raising this question was to check the management's sensitivity to operations.
- Question 7 checked the interactions among employees about shared values and norms concerning safety, as at the end of the previous empirical research project (P2) the assumption was made that everyone in this organisation has conversations about safety with colleagues in their own division. Therefore, the rationale for raising this question was twofold: to verify this assumption and to check the employees' preoccupation with failure.
- Question 10 probed for broad risk perception beyond the official ZPT risk matrix. P2 observed a clear tendency among the majority of ZPT-employees to have a broader view on risks. Therefore, the rationale for raising this question was to check the employees' anticipation attitudes.
- Question 11 probed for some kind of 'healthy distrust' (Conchie and Donald, 2006) among staff. One of the assumptions that was made at the end of P2 was that all employees are too familiar with each other, and therefore, not critical enough when it comes to controlling their peers. Therefore, the rationale for raising this question was to check the employees' sensitivity to operations.

Over the next sections I will highlight the main findings concerning these anticipatory attitudes.

4.4.1 Hierarchical lines and procedures

A recurring pattern in the answers to questions relating to reporting mistakes or potential safety issues is the formal hierarchical reporting as provided in the standard operating procedures (SOPs). These SOPs stipulate that all mistakes or near mistakes have to be reported to the operations supervisor or his adjunct. In turn, they have to report this to the hierarchy and at the Morning Safety Briefings where it is discussed by all maintenance and operations staff. Figure 4-1 illustrates this formal hierarchical reporting based on the first questions (Who would you report a mistake to?): maintenance people (MT) refer to each other, or to their line manager, and so do the Adjunct Operation Supervisors (AOS) as they report to their Operation Supervisor (OS), and the Administration staff (ADM) reports to their colleagues or to their line manager.

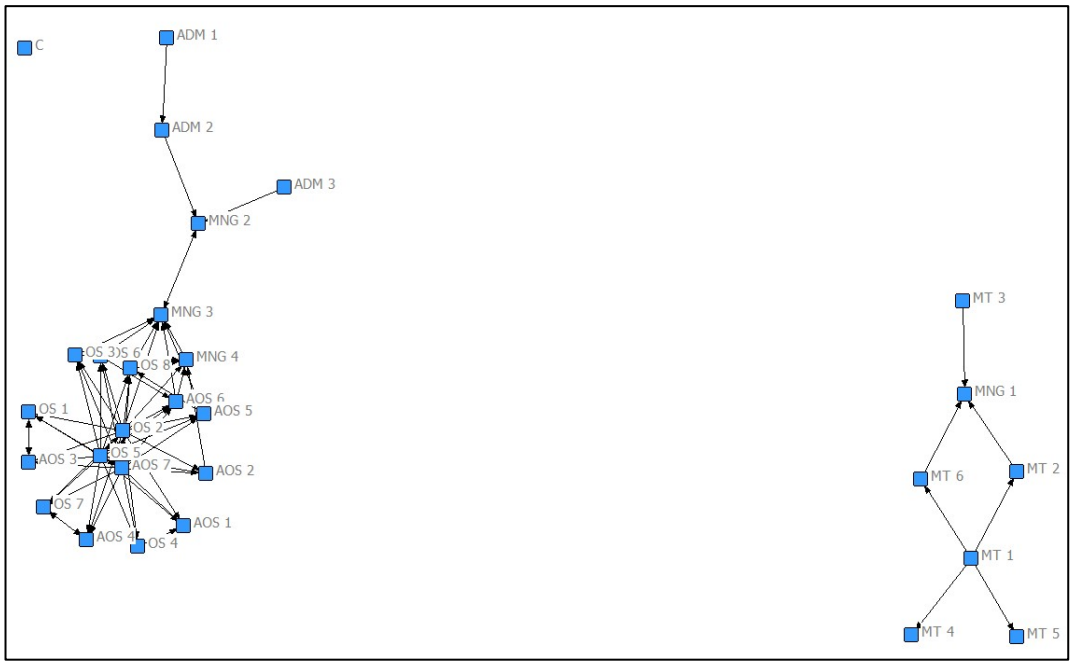

Figure 4-1 Q1: Who would you report a mistake to?

The data retrieved from Question 10 (alerting safety issues) offers a different but remarkable insight in the employees' attitude towards reporting safety issues. More than 82 percent (that is 23 out of 28 employees) gave exactly the same answer to the question: "Who do you inform when you have a safety issue or when you see an unsafe situation?" They all said: *"I would immediately*

address the person who is creating this unsafe situation!" To my subsequent question, "Imagine if this person is your CEO, would you do the same?", they all answered affirmatively. I reversed this question to the CEO by asking: Imagine one day you would act in an unsafe way. What is the reaction you hope to get from your subordinates? Without hesitation he replied: *"I would be very embarrassed the day this happens, but I do expect everyone in this company to correct me immediately."* This mental mindset of approaching everyone who does not show the right safety behaviour, and thus might create a potentially dangerous situation, is "ingrained in all ZPT staff's DNA" (interview OS4) and a clear example of anticipating unwanted events.

The second part of the employees' answer to this question reconfirmed the formal reporting of an unsafe situation or incident. ZPT's safety procedures indicate these types of situations as 'incident' that has to be reported in writing. Figure 4-2 nicely illustrates how this official reporting happens: according to the procedure in a hierarchical way. Some of the interviewees (predominantly maintenance people and adjunct operators) report an incident to an operation supervisor. These operation supervisors intervene when necessary, and subsequently log the event in a digital register. These logs are subject to formal discussion in the daily Morning Safety Briefing with operations, maintenance and the management team. Most of the Operation Supervisors directly report an incident both to their manager and/or to the HSEQ manager. The latter, in turn, immediately reports to the other members of the management team.

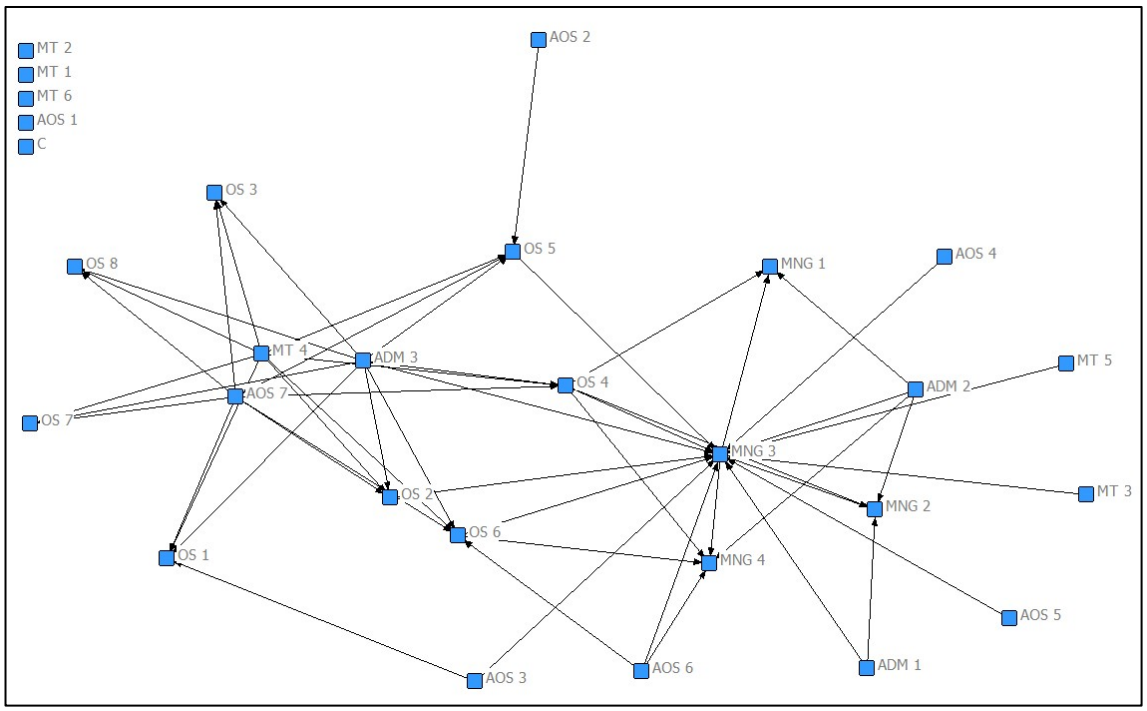

Figure 4-2 Q10: Who do you report safety issues or unsafe situations to?

Although there is a very direct way of approaching anyone who shows unsafe behaviour, the formal way of reporting such an incident happens in a standardised hierarchical way. According to AOS4 *"you don't go tell everyone when you see a safety issue. You immediately address the person himself, and report it to the HSEQ manager. When I see an unsafe situation, I'll try to fix it first before I officially report it in the incident log."*

4.4.2 Collective conversations

Safety is a vivid topic of discussion and mutual alignment in ZPT. This is illustrated in the network analysis graph of the question concerning who initiates discussions about safety and risks (see Figure 4-3), and is similar in the results of question number seven (talking to someone about safety). Figure 4-3 offers an almost unique illustration of how the entire organisation has an ongoing constitutive conversation about safety and potential risks. Everyone refers to others as the initiator of conversations about safety, and at the same time everyone is also indicated as an initiator of these types of conversations.

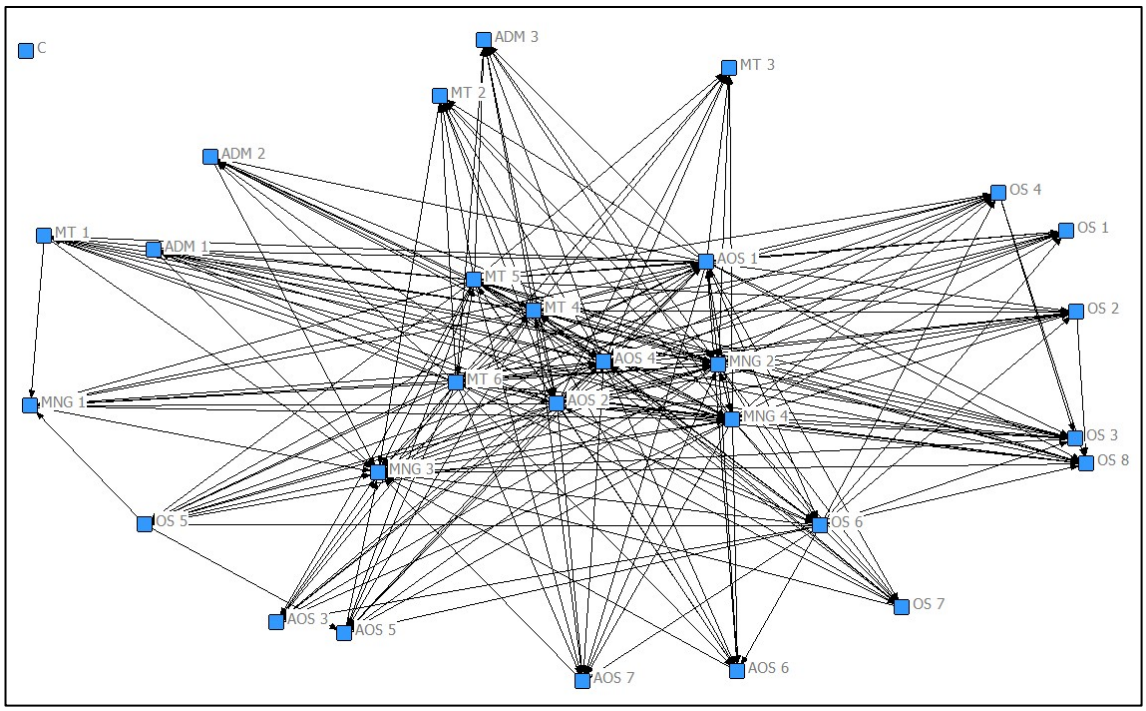

Figure 4-3 Q2: Who is most likely to initiate discussions about safety and risks?

Figure 4-4 (presenting the 'In Degrees', i.e. the number of times every individual is indicated by others) indicates how all employees are indicated by at least seven colleagues as initiators of discussions about safety and risk.

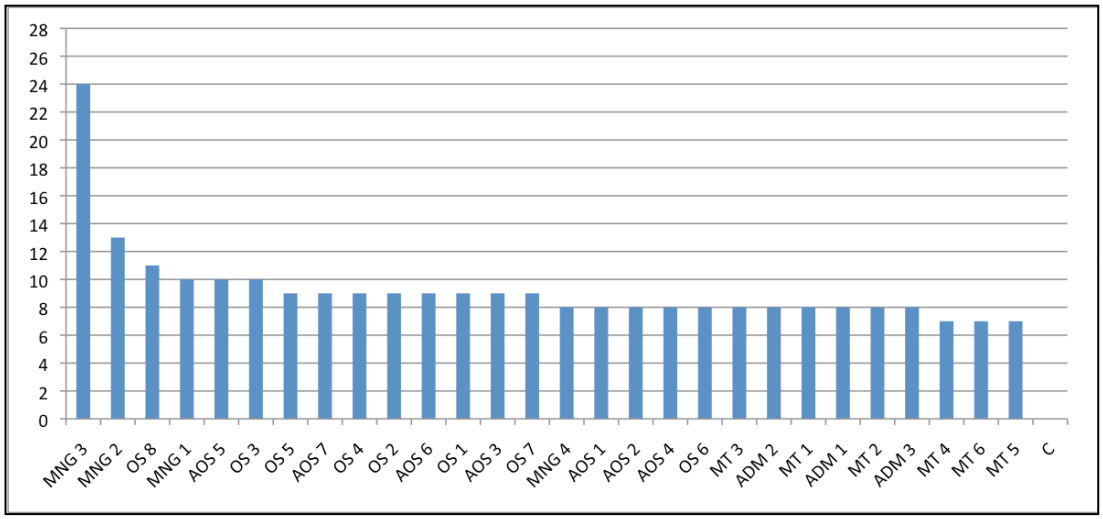

Figure 4-4 Q2: In Degree representation

A final observation concerning these collective conversations is that several employees who joined ZPT over the last few years are among the people who refer to all of their colleagues as instigators of safety conversations. Although they never attended Statoil's Safety Behaviour Programme, these "new entrees" absorbed this "safety dialogue" as they are frequently indicated as initiators of safety conversations.

4.4.3 Role of management team

In all data, the very particular role of the management team emerges as key to anticipate hazardous events, and by doing so, their contribution to the long-standing organisation's safety record. Besides a very clear hierarchical line of reporting, the management team previously installed and continuously supports a 'no blame no shame culture' in which all safety related issues are open for collective discussion and improvement. This involves all employees in an *"open safety dialogue"* (MNG2) in which every individual is responsible for reporting safety issues. According to the CEO, *"no individual in this company has to take all the responsibility, but they are all responsible for reporting mishaps or risks and for taking appropriate action."* One member of the maintenance team (MT3) reframed the CEO's expression as follows: *"making mistakes is not the end of the world, as long as you report them immediately and learn from your mistakes"* (MT3). And *"if a mistake is based on the wrong interpretation of a procedure, than we need to reinterpret and change the procedure"* (MNG2).

A second basic pillar of this safety culture is framed in the catchphrase "time and money are no excuse for executing a safe job". One of the ZPT employees recalled a story in which the executive team decided to interrupt construction work that involved more than 80 external contractors. As the safety conditions were not fully guaranteed, they were all sent home. *"Can you imagine the cost of temporarily interrupting such a major project? But still, it was a fraction of the real cost in case something really nasty had happened!"* (MT5).

And finally, the management team strongly promotes a *"no one is infallible"* (MNG3) attitude, starting with them. Meaning everyone is allowed to approach

them to point out flaws or mishaps. This is based on the management team's belief that every individual is fallible and thus will make a mistake one day. *"We are not gods, nor untouchables! As management team our responsibility is to keep this place safe by engaging every single individual in an open safety dialogue. The day we rely on past successes, things will go badly wrong"* (CEO).

4.4.4 Reporting minor mistakes

When evaluating the results of the data, captured by the two questions concerning the reporting of minor mistakes, in light of the anticipation principles, we might conclude that ZPT has created a system in which all employees are open to discuss and report minor mistakes to the hierarchical lines, which indicates their preoccupation with failure (HRO principle #1). Weick and Sutcliffe state "to avoid failure, you've first got to embrace it" (Weick and Sutcliffe, 2007; p. 46). Given the fact all employees indicate that they report minor mistakes, independently of social bonds or hierarchical positions, this suggests ZPT's sensitivity to operations (HRO principle #3). According to Weick and Sutcliffe it is "about detecting small discrepancies anywhere […] seeing what we are *actually* doing regardless of what we were supposed to do based on intentions, designs and plans" [emphasis in original text] (Weick and Sutcliffe, 2007; p. 59). This refers to reporting minor mistakes, even when this is not foreseen in the company's procedures, and indicates ZPT's conformity to being sensitive to operations.

In the penultimate paragraph of this chapter (4.7 Mindful organising) I will elaborate on the management team's attitude to anticipate hazardous events, and its impact on organisational safety in more detail.

4.5 Containment

In this section, the data retrieved from four questions of the social network interviews will be analysed and discussed. These questions (questions 4 and 5) are based on the last two HRO principles, as presented by Weick and Sutcliffe

(2007), and two questions that relate to findings of the previous research projects (question 13 is related to P1, the systematic literature review, and question 9 is based on findings from the previous empirical research project). All the questions refer to the two containment principles, as presented by Weick and Sutcliffe (2007). They "aim to prevent unwanted outcomes *after* an unexpected event has occurred rather than to prevent the unexpected event itself" [emphasis in original text] (Weick and Sutcliffe, 2007; p. 65). In this perspective containment is all about "large and varied response repertoires, competence in reassembling existing practices into new combinations, intense sharing of information, and a well-developed ability to maintain emotional control in the face of chaos" (Weick and Sutcliffe, 2007; p. 81). In other words, the principles of containment look at how employees are committed to resilience once an incident occurs, and how the organisation gives deference to expertise rather than to experts to contain critical situations.

Therefore, the questions that were asked probed for this attitude to prevent unwanted outcomes after an unexpected event occurred:

- Question 4 encouraged the interviewees to indicate the people in the organisation who go that extra mile to maintain normal operations. The rationale for raising this question was to gauge the employees' commitment to resilience.
- Question 5 checked who in the organisation turns to whom for support when facing a work related problem. The rationale for raising this question was to uncover the employees who are perceived as people with a lot of expertise.
- Question 9 probed for expertise in real-life crisis situations. One of the major findings in P2 was that employees who experienced a life-threatening crisis situation in a previous job had a more divergent view on the actual risks in the organisation. Therefore, the rationale for raising this question was to identify employees who are seen by their colleagues as capable to contain unexpected events.
- Question 13 aimed to identify employees who deserve respect for taking safety measures. This question was based on findings of the systematic

literature review (P1), indicating the importance of a leadership style that is based on expertise. Therefore, the rationale for raising this question was to identify the employees who are respected by their colleagues as safety experts, and capable to contain unexpected events.

As mentioned earlier, ZPT has operated for more than twenty years without experiencing any critical incident. *"The worst things we have encountered here are a couple of bruises and a dislocated ankle,"* admitted one of the veterans in the company (OS7). Therefore, the questions that were raised to gauge ZPT's containment attitudes were based predominantly on minor incidents and what if scenarios. All interviewees were encouraged to refer to colleagues, who clearly demonstrate these containment capabilities, such as maintaining normal operations, solving problems, or taking the right actions in case of a possible crisis situation. The rationale for asking these referring questions was dual; first of all to identify individuals or groups in the organisation who are perceived as people who are committed to resilience, and secondly to check to what extent ZPT-staff strictly stick to hierarchical lines, or rather consult colleagues with the appropriate knowledge to solve a specific work related issue. The latter orientation refers to the fifth HRO principle, which is 'Deference to expertise' (Weick and Sutcliffe, 2007).

The majority of the employees stick to the hierarchical line when searching for help in case something happens. Figure 4-5 (data retrieved from question number 5 - "Who would you turn to when facing a work related problem?") illustrates this by indicating transitive ties. An Adjunct Operation Supervisor will turn to the Operation Supervisor, who in turn goes to the COO, and the COO in turn goes to the CEO. The same pattern emerges for the Maintenance Team members who turn to the CTO, while the Administration people turn to the HSEQ Manager who is responsible for the administrative department as well.

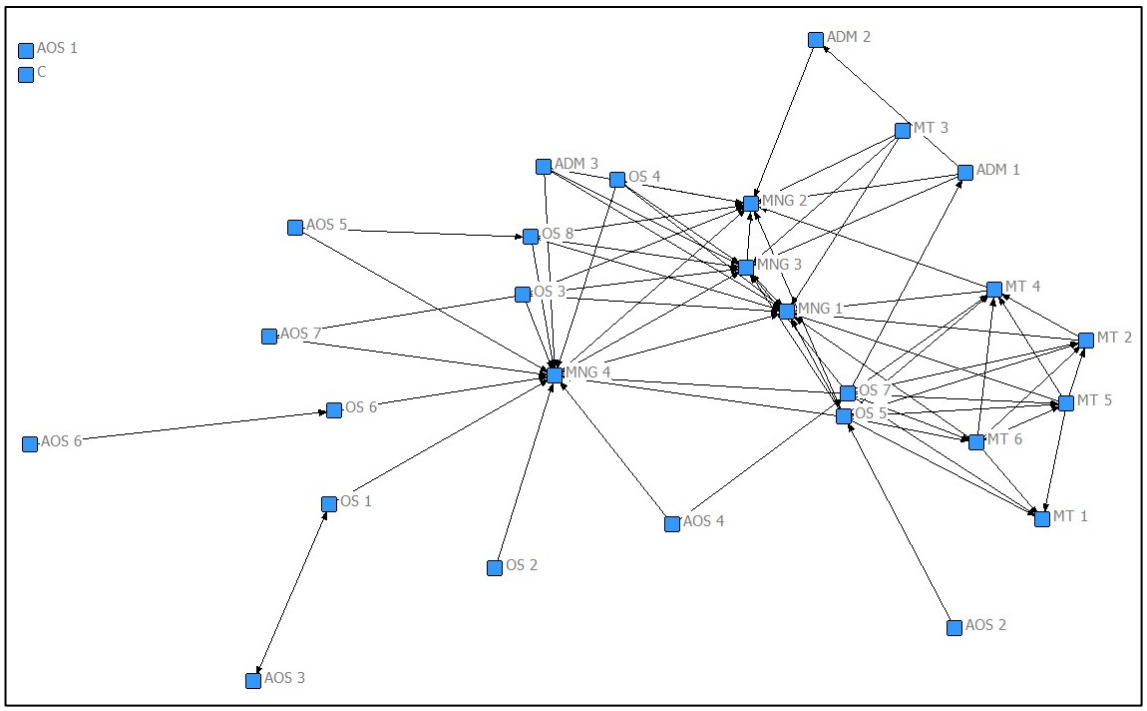

Figure 4-5 Q5: Who would you turn to with a work related problem?

Looking at the reciprocity set of ties (Figure 4-6), this supports the earlier interpretation concerning the hierarchical reporting, as there are only four mutual ties. This indicates almost everyone is reporting to his or her superior instead of a peer or friend. In the case of the reciprocal ties between MT5 and MT6, and OS5 and MT2 they all indicated that for specific work related issues they would most probably consult each other's expertise first before addressing their manager. For OS1 and AOS3 it seems to be logical to address each other as they always work together in the same dyadic team. They also say they address the line manager, but only if they cannot find a satisfying solution for the problem themselves. When it comes to the management team, one would expect they all address each other with a work related problem. The data (see Appendix H.6) indicates only MNG3 and MNG4 turn to their peers in the management team. The CEO (MNG2) declares he will *"turn to my superior in Norway"*; while the CTO (MNG1) says *"it depends on the problem. I'd rather expect my subordinates to approach me with a work related problem."*

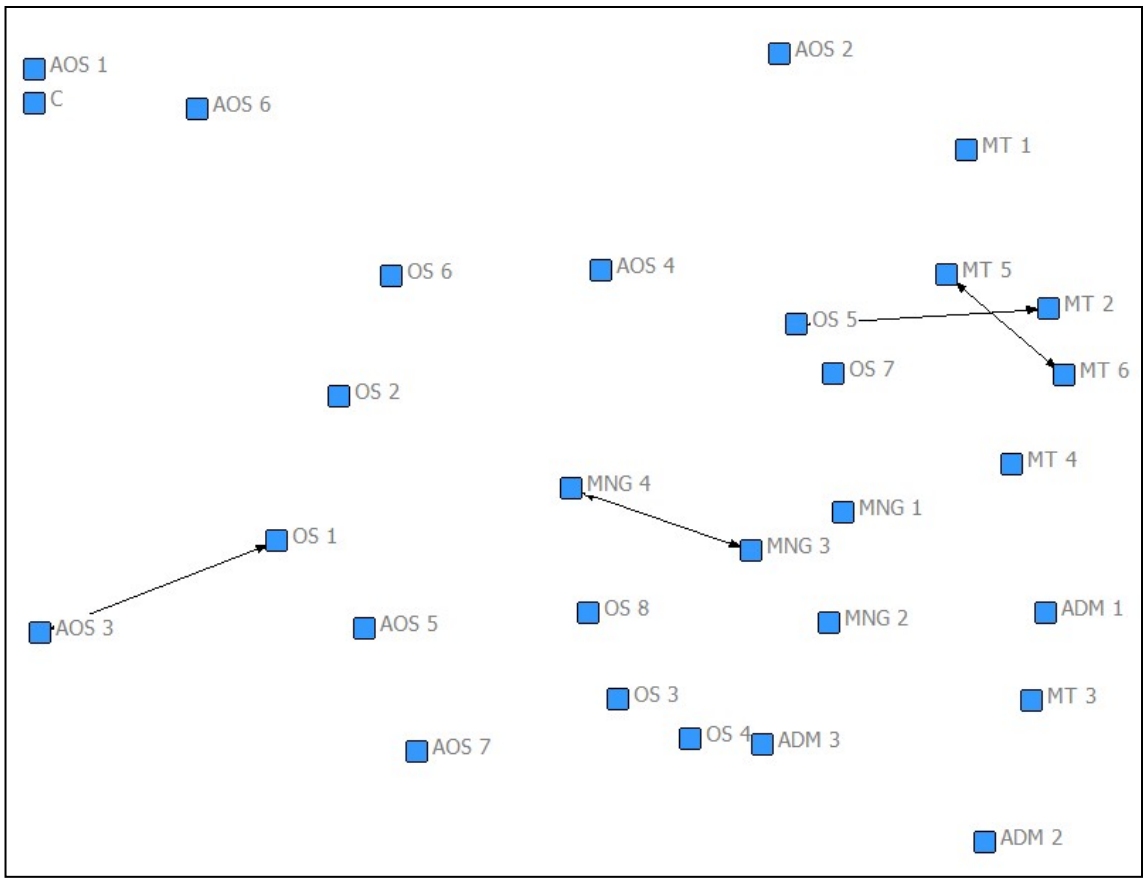

Figure 4-6 Q5: Reciprocity between actors

The CTO's quote, however, is at odds with the answers the maintenance staff gave on the second part of question five ("Who would turn to you with a work related problem?"). Here, various people in the maintenance department and the operations department indicated the CTO (MNG1) as a person who looks for help with a work related problem, while none of the other executive members are perceived that way. This supports my previous interpretation of a flat horizontal organisational structure when it comes to solving problems and work related issues (see: "4.4.1 Hierarchical lines and procedures").

The aim of these questions concerning whom to approach when facing a work related problem was to probe for ZPT's attitude for deference to expertise (HRO principle #5). The results indicate that a dominant majority of ZPT staff feel comfortable when his or her colleagues consult him or her for work related problems, even when this happens outside official hierarchical lines.

Furthermore, it also illustrates how all staff makes an effort to articulate work issues with their colleagues, and by doing so transcends the divisional barriers.

4.6 Trusted social relationships

In this section, the data retrieved from two questions of the social network interviews will be analysed and discussed. These questions (questions 6 and 12) are related to findings of the previous research project (P2) and probed for trusted social relationships among ZPT employees. As the average years of employment at ZPT is 15, my assumption was that the majority of the staff has close social relationships both inside and outside work.

Therefore, the questions probed for these trusted social relationships among staff:

- Question 6 encouraged the interviewees to indicate the people in the organisation they go to with personal, and thus not work related, problems.
- Question 12 aimed to identify the employees who socialise outside of work.

For the first question (who do you turn to with a personal problem?), a large group indicated they keep work and private life separated, and thus do not discuss personal issues with their colleagues (see Figure 4-7). Only a handful refer to their direct colleague they share the office with. Most of them have worked together for several years, often during weekends or night shifts. These respondents indicate: *"You get to know each other so well after a while, you can't hide personal problems. You become buddies, and sometimes share more with each other than with your spouse"* (AOS3).

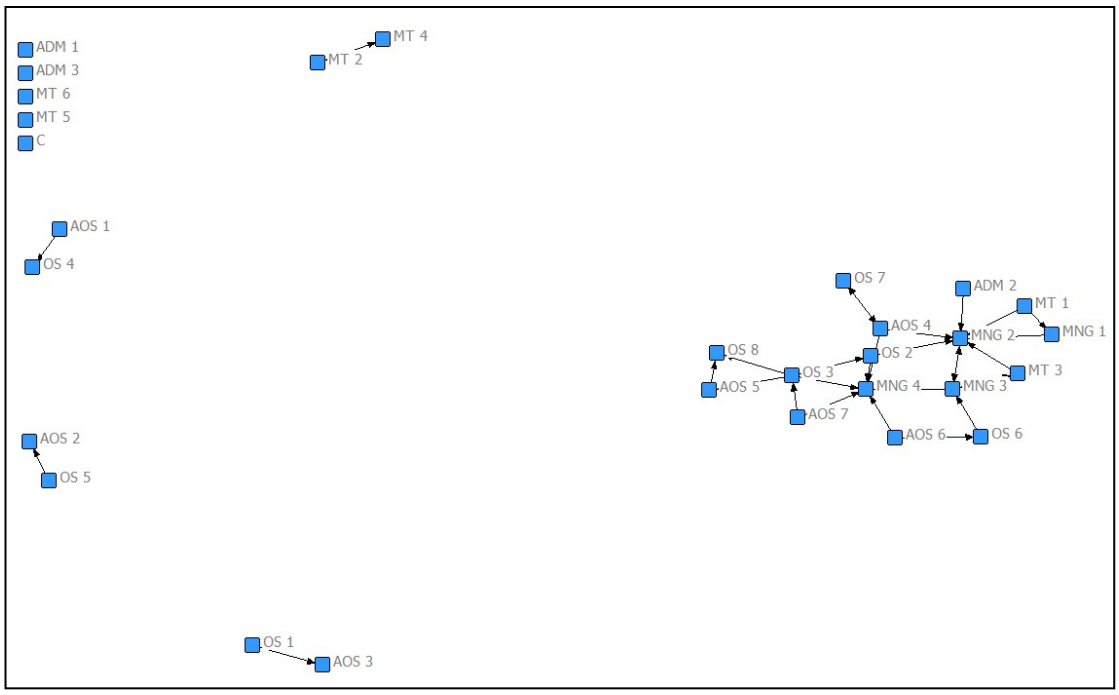

Figure 4-7 Q6: Who would you turn to with a personal problem?

Others refer to members of the management team, and especially to the CEO and the COO. Both worked as Operation Supervisors in the control room for years, and they continued to have good relationships with their former colleagues. One Operation Supervisor admitted: *"Our CEO has this precious gift to 'read' your mind. You can try as hard as you can to hide your personal sorrows, but he will approach you with a compassionate question for sure. The nice thing is you know your personal trouble is safe with him. It will not be used against you, on the contrary!"* (OS2).

When it comes to socialising outside of work, another picture appears (see Figure 4-8). A small group linked to the COO (MNG4) does connect outside of work. *"Together with our spouses, we make a three to four day city trip once a year. And the golden rule is: no conversations about work!"* (MNG4). Others occasionally meet outside of work for various reasons; they live close to each other (ADM2 and MNG1), they follow the same photography course (MT2 and MT4), they refer to a dinner they have once or twice a year, together with their partners (OS8 and AOS5), or to an occasional drink after work *"on a Friday*

afternoon, when the weather is fine, and we fancy a cold beer or two" (AOS1 and OS4).

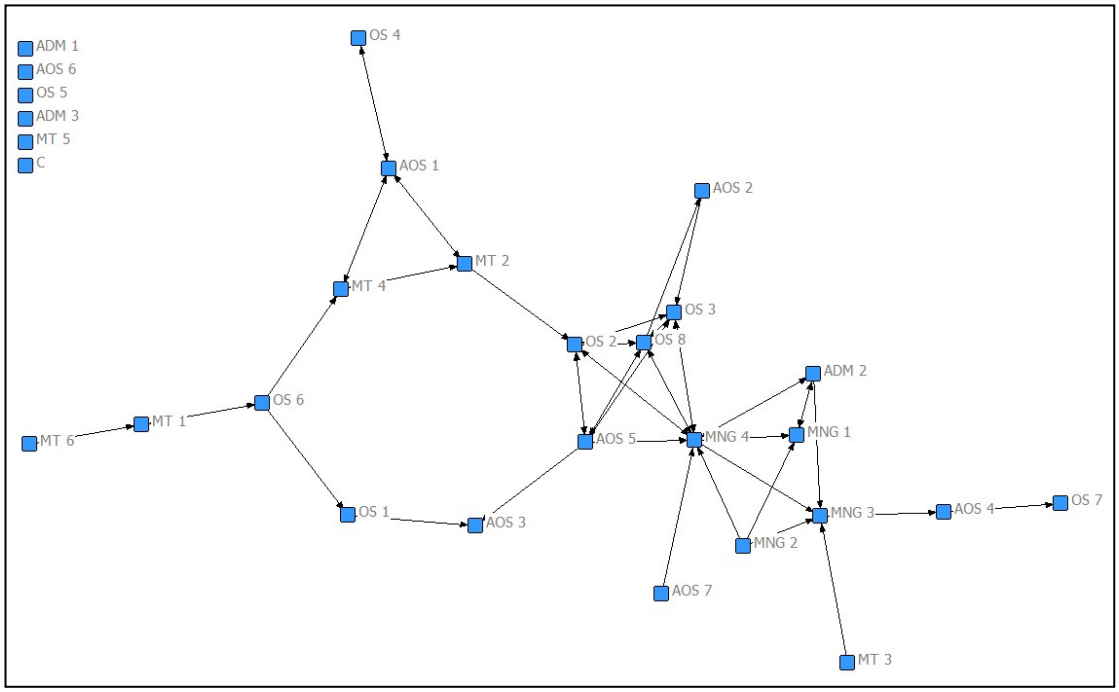

Figure 4-8 Q12: Who do you socialise with outside work?

Although ZPT organises a couple of off-site events for all employees every year, some complain about the lack of social coherence, while others prefer to keep work and private life strictly separated. The latter indicated they seldom join these off-site events.

A final remark is the position of the CEO. He indicates the three members of his management team as colleagues he sometimes socialises with outside of work, while none of them refer to the CEO. There might be several explanations for this, but the most probable one is that none of the management team members perceive off-site meetings as a form of socialising, but rather as *"informal discussions about work related issues"* (according to one of the managers).

In an attempt to gauge the impact of social relationships on the willingness to report minor mistakes, the data retrieved from Question 12 (Who do you socialise with outside of work?) was combined with the data of questions that probed for reporting mistakes. As a result, Figure 4-9 illustrates the ties

between staff that socialise outside of work and would report minor mistakes to each other (Question 1). It might be argued that these personal ties have no impact on the reporting process, as all respondents refer to more colleagues than just their close friends. In other words, Figure 4-9 only shows a fraction of the reporting ties.

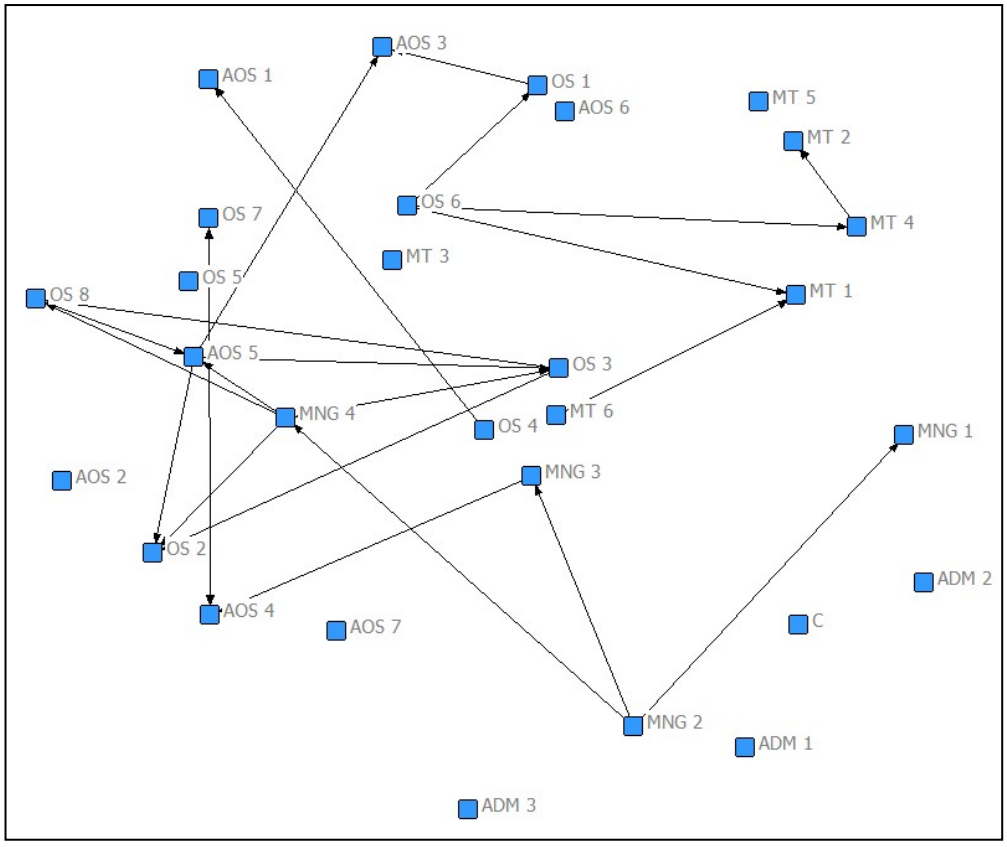

Figure 4-9 Q1 combined with Q12: Influence of social relationships on reporting minor mistakes

The evaluation of the possible impact of social relationships on reporting safety issues (Question 10) does not indicate a significant correlation. The connections as presented in Figure 4-10 represent a small part of all the relations that were indicated by the various employees. Therefore, it might be argued that there is no difference in reporting safety issues when it comes to social relationships.

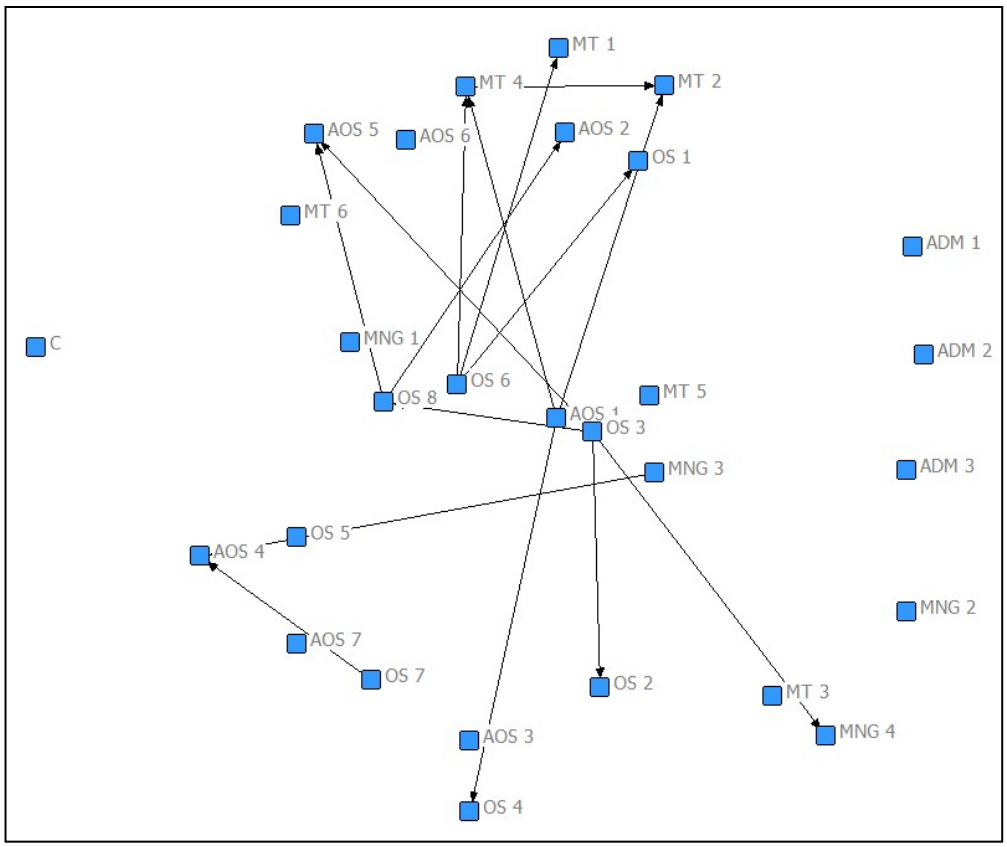

Figure 4-10 Q10 combined with Q12: Influence of social relationships on reporting safety issues

4.7 Mindful organising

To achieve high reliability, Weick and Sutcliffe (2007) indicate 'mindful organising' as an overarching prerequisite. Mindful organising supports a different mindset about the things that can bring an organisation into jeopardy. It is about a set of attitudes, such as "human alertness, experience, skill, deference, communication, paradoxical action, boldness, and caution" (Weick et al., 1999; p. 105-106), that aim to foresee the unforeseeable. This attitude of mindful organising encourages organisational members to detect flaws or minor mistakes that they may have missed before, and by doing so it prevents an organisation from unwanted events. Hence, it describes a corporate culture in which safety values and expectations about risk aversive behaviour and early (mindful) detections of flows are encouraged. In an attempt to install and maintain such a corporate culture, Weick and Sutcliffe denote five elements that

have to be put in place as a prerequisite to produce a culture of mindful organising. These elements are: thinking differently about 1) success, 2) simplification, 3) strategy, 4) plans, and 5) authority (Weick and Sutcliffe, 2007; p. 148).

In an attempt to gauge ZPT's ability for mindful organising, all the interviews and ethnographical data were analysed and encoded according to two sets of elements: the prerequisites for creating a culture of mindful organising (Weick and Sutcliffe, 2007), and attitudes to foresee the unforeseeable (Weick et al., 1999). Every interview was transcribed and encoded with Dedoose software. When there was an overlap in two sets of interviews, for instance when an interviewee discussed a specific topic or example twice in two separate interviews, solely the section of the first interview was encoded. Although the aim of encoding the data was not to achieve numerical representative data, the rationale for excluding double identical sets of data was to obtain a more balanced view. Table 4-2 shows the results of this encoding process. Every number indicates the overall frequency interviewees referred to a specific element.

	Attitudes that aim to foresee the unforeseeable								Prerequisites for producing a culture of mindful organising					
	Alertness	Boldness	Caution	Communication	Deference	Experience	Paradoxical action	Skill	Authority	Plans	Simplification	Strategy	Success	Totals
MNG 1				4	3	3		2	2	1		1		16
MNG 2	5	1	4	7	6	4	1	2	11	6	3	10	2	62
MNG 3	1			3	1	1	2	2	2		1		1	14
MNG 4	1			2	2	1	1	3	3	1		1		15
OS 1	1			1	1	2		2						7
OS 2		1		2	4	6		3	2					18
OS 3		1	1	2	1	3		3	1					12
OS 4	3		1	3	2		2		3					14
OS 5	1		1	2	1	2		1		1		2		11
OS 6				1		3		1				1		6
OS 7	2		2	1	1	2			2			1		11
OS 8				2										2
AOS 1				3	1	1			1					6
AOS 2	1			1										2
AOS 3	1		2	2	1	2		1						9
AOS 4		2		4	2	1			2	1		3		15
AOS 5	2		3	2					1			3		11
AOS 6	5		3	3	1	2			1					15
AOS 7				1	1	1	3	1	2			4	1	14
MT 1			1	3	1	2		2	1			2		12
MT 2	2		2	5	4	2	1	1	1			3		21
MT 3	1	1	1	3	1	3	1	2	1	2	1	1		18
MT 4	1		1		1	1		1	2			2	2	11
MT 5	1			3		2		4	1			1		12
MT 6				1	2	2		1	1		1	2		10
ADM 1						1		1	2			1		5
ADM 2	4	2	1	2	1	4		1		1		4		20
ADM 3				2					1			1		4
Totals	32	8	23	65	38	51	11	34	43	13	6	43	6	

Table 4-2 Encoding results of the qualitative data

In the next sections I will discuss each set of elements separately.

4.7.1 Attitudes

It might be argued that foreseeing something unforeseeable (Weick et al., 1999) is an almost impossible task, as the latter is intrinsically linked to something that is not possible to anticipate or predict. Therefore, Weick and his colleagues indicate a set of attitudes (human alertness, experience, skill, deference, communication, paradoxical action, boldness, and caution) which, when they are present among staff, might provide warning signs of possible flaws or danger (Weick et al., 1999).

The interview data of this research project indicates how all these attitudes are present among staff, predominantly in combined sets. An example of this is when someone recalls how he or she interacted with a colleague concerning something that involves deference to the other person's expertise, based on a concept of being cautious in operations, and alertness. The following example illustrates how an Adjunct Operation Supervisor mentions communication, deference, alertness and caution in one single quote: *"In fact, I do talk to everyone about safety. When I see someone from maintenance who might be involved in my project, I will definitely approach him about certain issues that might pop up. These guys know all the ins and outs of our plant, better than anyone else. Recently, a couple of contractors had to do a repair job on the metering installation. It was a rainy day, and I was worried about how to avoid water in the installation. I discussed this with my colleague and warned the on-call maintenance guy."* (AOS6)

The most frequently mentioned elements are communication and experience. As already indicated in the findings of the social network analysis, the threshold level among employees for approaching each other to indicate potential dangerous behaviour of risks is very low. One member of the maintenance staff articulated it in this way: *"When I see someone doing something stupid, I will immediately say 'you're not doing a good job, pal!' This will be reported anyway. And if it concerns serious misconduct, I will immediately inform our HSEQ manager; to say 'that guy over there is definitely not doing it right'. In my view,*

that's what needs to be done. Irrespective of who's doing something stupid" (MT3).

Formal communication in terms of alignment concerning the safe execution of jobs is also mentioned quite often. It illustrates how standardised processes are constantly discussed, aligned, and evaluated prior to the start of a job, and thus indicates a mindful attitude. *"Every morning, the COO passes by, just to check if we are expecting anything special that day. The same story with our CTO. And our morning meeting of course where we discuss various issues"* (AOS5). One operation supervisor added: *"A recurring topic at the morning meetings is the question how we might improve safety. Quite often Jan, our HSEQ manager, starts this conversation by introducing a randomly chosen issue. It also happens that a minor incident becomes the theme for an in-depth discussion on how to improve things"* (OS3).

The element of 'experience' is predominantly linked to know-how of the job, such as *"I will explain to them what I experienced, and how I solved it, more in the sense of making sure they will not fall into the same trap as I once did"* (OS6). Still, experience is also often linked to insights and knowledge acquired in trainings and subsequently applied to the job: *"Trainings and exercises clearly indicate the [safety] direction we're aiming for"* (MT5), and *"We all have more or less the same level of knowledge, based on the trainings we all followed here in the company. But luckily, everyone has different skills. Both, skills and knowledge, give us all the required experiences to manage this plant safely"* (MT6).

4.7.2 Culture

When it comes to thinking differently about success, simplification, strategy, plans, and authority (Weick and Sutcliffe, 2007), it is remarkable how many employees at ZPT mention authority (21 out of 28) and strategy (18 out of 28). In almost all the interviews, both aforementioned elements are linked to management actions, initiatives or vision. The following quotes support this: *"there is no blaming culture in this company"* (MNG3), *"We don't have a 'normal'*

hierarchy in this organisation; new entrees can learn as much from employees who have been working here for more than fifteen years, and vice versa. You will find that attitude in our management team as well" (OS2), and *"Our management team made it very clear that safety is everyone's responsibility"* (MT6). This last quote is confirmed by *"We are all safety officers in this organisation"* (AOS1).

It might be argued that the elements for producing a culture of mindful organising, as described by Weick and Sutcliffe (2007), are predominantly linked to management actions. Envisioning success, simplifying processes, adapting and implementing a strategy, making organisational plans, and exerting authority, are all typical leadership or management tasks. That might explain why predominantly members of the management team referred to these elements to produce a culture of mindful organising (see Table 4-2).

A concluding consideration is linked to Antonsen's (2009) connotation of "a 'good' safety climate" (p. 17). Antonsen argues that a common mindset about safety can only flourish in a "'good' safety climate […] where managers at all levels are highly committed to safety; where the workforces express satisfaction with and adherence to the organisation's safety system; where everyone is risk averse; where there is no pressure towards maximising profits at the expense of safety and where operators as well as managers are highly qualified and competent" (Antonsen, 2009; p. 17). In various interviews, both in P2 and P3, several employees quoted the company's unofficial catchphrase "time and money are no excuses for executing a safe job", while underlining the management team's dedication to safety no matter what. That supports Antonsen's description of a safety climate.

4.8 Conclusion

The findings of this research indicate how all ZPT-staff interrelate when it comes to constituting a shared understanding of risks and safety issues. Although there is a formal hierarchical structure of reporting and managing the day-to-day activities, and every work related action is based on agreed

procedures or guidelines, every individual takes part in a horizontal-like discussion on safety. By doing so they achieve a form of collective coordination that is based on the five principles of HRO. However, these HRO principles, as such, are unknown by ZPT's management team. Given the fact that ZPT has operated accident-free for more than twenty years, they have the benefit of the doubt that these high-reliability attitudes keep the plant and its operations safe.

The role and position of the Management Team is also noteworthy. Depending on the topic, they all have a more or less subtle presence in the middle of each map that is linked to conversations about safety and work related issues. This indicates their key-supporting role in maintaining safe operations. The management team facilitates the conversation, but they are not perceived as the key people that own the conversation.

A final overall observation is the position on the various maps of employees that experienced a real life threatening crisis situation at a previous job, and those of the employees that joined ZPT after 2004. They are all well mixed on the various graphs, and nobody is outlined as an 'expert', or as 'outsider'.

5 INTERPRETATION OF THE FINDINGS

5.1 Introduction

In this chapter I will link the findings of this research back to the earlier described ‘soft barriers’ (Statoil, 2002) and the HRO principles (Weick and Sutcliffe, 2007) (see Chapter “4: Findings”) in an attempt to evaluate ZPT’s current level of congruence, and to indicate the significance of these findings. Furthermore, I will interpret ZPT’s capability to maintain safe operations from a process ontological point of view.

5.2 Alignment to HRO principles

This research is aimed at uncovering how maintaining safe operations is achieved in an organisation managing high-risk processes. As indicated at the start of Chapter 4, Statoil’s Safety Behaviour Programme (Statoil, 2002) apparently made an impact on ZPT’s current executive team and all other employees that attended this safety workshop in 2004. The soft barriers to safety behaviour, which were the basic tenants of this Safety Behaviour Programme, are very similar to Weick and Sutcliffe’s (2007) principles for high-reliability organisations (HRO). Although ZPT’s management team is unaware of these HRO principles, they have installed and supported these principles over the last decade.

Although Weick and Sutcliffe do not explicitly mention the concept of communication that constitutes an organisation, all the HRO principles are rooted in “a capacity to anticipate unexpected problems” (Weick and Sutcliffe, 2007; p. 17) by their efforts to act mindfully. Weick and Sutcliffe describe mindful as a “striving to maintain an underlying style of mental functioning that is distinguished by continuous updating and deepening of increasingly plausible interpretations of the context, what problems define it, and what remedies it contains” (Weick and Sutcliffe, 2007; p. 18). In a prior theoretical paper (Weick et al., 1999) introducing the high reliability principles, Weick and his colleagues argue, “collective mindfulness is a complex and rare mix of human alertness,

experience, skill, deference, communication, negotiation, paradoxical action, boldness, and caution" (Weick et al., 1999; p. 105-106). In other words, this continuous updating and deepening of plausible interpretations of the context through a set of personal skills is not only an individual mental act, but also an interactive act in which two or more people mutually adjust their contextual insights. This set of interpersonal skills is what Weick and Robberts (1993) refer to when they introduced the concept of 'heedful interrelations'.

Weick and Roberts (1993) define this mutual interactive process as "heedful interrelations of actions in a social system", a collective investment in "time and effort to organise for controlled information processing, mindful attention, and heedful action" (Weick and Roberts, 1993, p. 357). Therefore, this mutual adjustment through interpretative heedful interrelation is a relational and, in the moment, adjustment to situations that change through communication. It is more an interactive process, rather than a top down communication aiming to standardise safety behaviour. Although Weick never explicitly referred to CCO, it might be argued he adheres to this view on communication which constitutes organisations as he asserted, "the communication activity is the organization" (Weick, 1995; p. 75).

Finally, Weick and Sutcliffe (2007) forewarn that routines and plans might lead to a certain form of complacency in which "people assume that the world today is pretty much like the world that existed at the time the routine was first learned" (Weick and Sutcliffe, 2007; p. 26). This attitude is basically the opposite of mindful action and might bring an organisation into jeopardy. However, this research indicated how ZPT continuously adapts its operating procedures and guidelines based on various safety conversations, formal safety reports, and discussions in the daily safety meetings and management meetings. Therefore, the 'traditional' communication that focuses on a mere transfer of safety guidelines and procedures is but a part of the full story on risk communication. There is also a constitutive form of communication present at ZPT, one that coordinates safety behaviour and that seems to lead to accident free operations.

5.3 From a process ontological point of view

Putnam and Nicotera (2010) described a constitutive view of 'communication-as-verb', hence emphasising the process oriented ontological perspective of communication. This interpretivist view of communication, and thus of organisation as communication (Blaschke et al., 2012), is apparent at ZPT. Despite the fact all employees have divergent perceptions of risk (see Part III of this thesis) they have a unique way of interacting with each other with regard to safety and risk aversive behaviour. The extensive links among all organisational members concerning the initiating of safety conversations, as presented in the previous chapter, illustrate how this safety dialogue has pretty much become second nature to all ZPT staff. Through these continuous interactions they have learned to express their thinking, to share their expertise, and to be reluctant to simplification and preoccupation with failure.

Therefore, from a process ontological point of view, it might be argued that ZPT (non-intentionally) created a form of 'communication-as-verb' (Putnam and Nicotera, 2010) which is focused on the creation of mutual understanding concerning risks, the avoidance of unsafe behaviour, and the elimination of potentially risky situations through a continuous safety dialogue.

6 DISCUSSION

In this chapter I will link the findings of this research to the literature that was discussed in Chapter 2 (on pages 231-234). I will also touch on a personal appeal to demolish the theoretical wall between the two distinctive views on communication, the informational and the constitutive view, when it comes to support safety behaviour in organisations managing high-risks. I will then highlight two major contributions to the existing literature on HROs. The chapter will end with limitations to the research, and recommendations for practice and further research.

6.1 Introduction

This empirical research offers substantial answers to the research question. It indicates how all employees engage in an organisation-wide conversation on safety and risk avoidant initiatives. These conversations are supported and made possible by the management team, and through these ongoing conversations, all employees constitute a culture that allows to discuss, criticise, and challenge current practices that might have a negative impact on the organisation's safe operations. Furthermore, the operations and maintenance staff have been given the space, time and resources to focus their 'activity coordination' (McPhee and Zaug, 2001) to a permanent level of preoccupation with failure while being reluctant to accept simplifications (Weick and Sutcliffe, 2007). By doing so, they voluntarily create a continuous mode of anticipating exceptions and problems, and in this continuously coordinate adjustment, not out of the ordinary as Perrow (1967) indicated, but rather as the result of the constitutive communication process that creates coordinated behaviour and safe operations.

6.2 Mutual adjustment

In the introduction chapter I referred to Mintzberg's concept of 'mutual adjustment' as one of five coordinating mechanisms in organisations. According to Mintzberg, "mutual adjustment achieves the coordination of work by the

simple process of informal communication" (Mintzberg, 1993; p. 4). This research suggests that mutual adjustment is more than a "simple process of informal communication", it is more a complex interactive process supported by the management team, based on an ongoing constitutive conversation about safety and risks, and rooted in the basic principles of HRO (Weick and Sutcliffe, 2007). In that sense the interpretation of 'mutual adjustment' in HROs is more a real time conversation in a complex work environment that is not only changing the situation (Denyer et al., 2011) but one that is constituting the work processes itself. The findings of this research indicate how all employees report to have an open dialogue on safety and risks. In doing so, they not only concentrate on observing "early warnings of the unexpected" (Weick and Sutcliffe, 2007; p. 57), they constantly interact in an attempt to articulate their interpretations and experiences concerning potential risks and safety more clearly. These real time conversations create the work process, and thus, coordinate behaviour itself.

6.3 Interactive process

The constitutive view of communication approaches its informational counterpart as a mere product of communication (Putnam et al., 2009) in which messages are transferred between a sender and one or more receivers, and key messages are created with the aim to inform or convince, but not to constitute the reality of the organisation or parts of it.

Still, Blaschke and his colleagues argue, "all communication processes are embedded in a wider societal context from which they can draw on readily available templates of meaning" (Blaschke et al., 2012; p. 883). From that perspective, this research (in combination with the results of P2) supports this view as it indicates how maintaining safe operations, which is grounded in a constitutive form of communication, seems to be viable when it is underpinned by known safety procedures and guidelines. Although it might be argued that the conception of procedures and guidelines fits the constitutional view of communication (see McPhee and Zaug, 2001; p. 588, on how policies,

procedures and manuals are media for ‘organisational self structuring’, which is one of the four flows in their proposed CCO framework), the dissemination of those documents is a typical example of the informational view of communication. This argument might be illustrated by the following example. During one of the interviews with an Operation Supervisor, he recalled a recent minor incident that happened over the weekend.

> *“During the night and over the weekend, it’s just me and my adjunct who are on the plant. When something happens, we can rely on the on-call duty manager. That particular weekend we had an alert in the LVS, the land valve station, (this is the station outside the ZPT premises where the sea pipe comes on land, note researcher). My adjunct went to the LVS and detected a burning smell. We called the on-call duty manager and for more than half an hour we had a conversation on how to solve the issue. Immediately we were on the same ‘wavelength’. We went through the procedures, examined plausible actions, and tried to make sense of the situation. At the end we jointly agreed to diminish the pressure in the LVS, keep a close eye on the conditions of the LVS, and bring in an external technical team in the morning. Although the procedures didn’t give us a ready-made answer to the problem, they helped us to achieve agreement through a common vision, call it a knowledge base. A couple of days later, we discussed how to adapt a few procedures based on this experience.” (OS2)*

This conversation, based on knowledge from description (procedures) and knowledge from acquaintance (Baron & Misovich, 1999), and coordinated collective interactions between team members (Weick, 2011), is what McPhee and Zaug (2009) call ‘activity coordination’. In that perspective, this minor incident, as recalled by Interviewee OS2, is illustrative for what McPhee and Zaug describe as members that “are working not just on related tasks but within a common social unit with an existence that goes beyond the work interdependence itself” (McPhee and Zaug, 2009; p. 39).

Therefore, it could be argued that the barriers between both views on communication are predominantly theoretical and therefore not really helpful when applied in an organisational context such as ZPT. High-reliability organisations might benefit from applying a more integrated approach of communication in which this 'activity coordination' (McPhee and Zaug, 2009) translates both views of communication to a rather 'interactive process' for obtaining safe operations. This would be more in line with Process Organisation Studies (Langley and Tsoukas, 2010) that focus on inter-actions to analyse coordinated behaviour, and emphasises narrative forms of knowing.

6.4 Contribution

This research project offers two major theoretical contributions:

First of all, it empirically indicates how Weick and Roberts' concept of 'heedful interrelations' (1993) might operate in an organisation managing high-risk processes. When Weick and Roberts (1993) introduced the concept of 'heedful interrelations', their arguments were based on extensive qualitative research in military organisations (more specifically nuclear-powered aircraft carriers) (Roberts et al., 1994). However, the focus of their research was not coordinated behaviour, it was based more on the cognitive factors that affect the decision processes. Therefore, Weick and Roberts did not indicate how these 'heedful interrelations' lead to collective coordinated safe operations in organisations managing high risks. They demonstrate how pilots of aircraft carriers develop mental processes that allow them to take the right decisions in milliseconds, based on controlled information processing, mindful attention and heedful action (Weick and Roberts, 1993). This research, as distinct from Weick and Robberts (1993), shows how heedful interrelations encourage employees to engage in an organisation-wide conversation on safety and risk avoidant initiatives, which in turn leads to maintaining safe operations in a high-reliability organisation.

Second, this research is the first of its kind that empirically demonstrates the constitutive role of communication for maintaining safe operations in a high-reliability organisation. A couple of similar studies have been published or

presented, but all with a different approach concerning the type of organisation or theoretical approach. One of the studies close to my topic is Jody Jahn's PhD dissertation (2012) on team coordination among wild land fire fighters by using a CCO lens. However, her study was based on critical incident narratives and workgroup-level safety climate among fire fighters. It might be argued that a fire fighter team is a distinct kind of organisation that is not comparable to a gas-receiving terminal, as the latter works on a normal routine aiming to prevent malicious events, while the former is predominantly working on solving malicious events.

Another domain of research that is close to my topic is an ongoing debate on how to apply the CCO view to study clandestine organisations, such as al Qaeda, as an organisational phenomenon that exists under extreme circumstances (Schoeneborn and Scherer, 2010; Stohl and Stohl, 2011; Schoeneborn and Scherer, 2012). However, these kinds of terrorist organisations clearly distinguish themselves from legitimate organisations such as ZPT as they lack a reflexive self-structuring way of organising (McPhee and Zaug, 2009), and they are not exactly in the same business of provision of services as ZPT is in.

A final piece of empirical research in the domain of coordinated behaviour based on a communicative approach is the work of Amanda Porter (2012). She studied the experiences of volunteers as part of an emergent organisation at a shelter during the response to Hurricane Katrina in New Orleans, August 2005. Still, Porter did not approach this research through a CCO lens, but through a situational boundary-making approach. Furthermore, it could be argued that a group of volunteers in a temporary organisation trying to mitigate the effects of a disaster is thoroughly different from a group of employees working together for almost two decades in the same organisation managing high-risk technologies.

6.5 Limitations

Although all efforts were made to present a well-structured and underpinned empirical research project, I am very well aware of the fact it contains multiple limitations.

First of all, the research was done in a very small organisation (30 employees). Although ZPT has all the functions and structures of a larger company, and it is part of a large state-owned company in Norway, the findings are not necessarily replicable to other similar organisation.

Secondly, for this research project the content of Statoil's Safe Behaviour Programme (2002) was evaluated through conversations with various ZPT employees who participated at that particular event in 2004 and through archival data. I also had the opportunity to examine the programme's brochure and five DVDs that explained the aforementioned 'soft barriers' and the setup of the programme. I was , however, not able to examine the body of knowledge and the underlying rationale for these workshops. Therefore, it would be of great value to attend this Safe Behaviour Programme, even ten years on, have a conversation with the programme's sponsors, and examine the content, structure, and theoretical as well as the practical underpinning of this seminar.

And finally the mixed use of various data sets, such as ethnographic data, qualitative data, social network data, and archival data, sometimes offers too complex a picture in which it is almost impossible to combine, link or extract the right data in the right circumstances. I observed people saying A in the network analysis, while doing B in their daily work. Therefore it might be argued that in this type of research the use of a single method for retrieving data only offers indicative answers. While a mixed use of data collection methodologies might blur a correct interpretation.

6.6 Recommendations for practice

The findings and discussion section of this research offer two distinct types of recommendations: for ZPT in particular, and for the wider industry.

6.6.1 Recommendations for ZPT

As mentioned earlier in the findings chapter, the management team facilitates what they call ‘an open safety dialogue’. This dialogue is well supported by the HESQ manager and the CEO. The question could be raised what would happen when one will be replaced by someone who is not that familiar with this specific safety culture and with the way all staff maintain safe operations through organisation-wide conversations? Knowing that the CEO will retire in a couple of years, this might be a strong recommendation in the search for succession.

When it comes to the HSEQ manager, he has a key role in ‘feeding’ this safety conversation. One interviewee mentioned:

> *“He has a massive knowledge of risk aversive measures, procedures, and technical insights. And moreover, he always challenges us to reflect on how to do things in a better and safer way.”*

Currently, the HSEQ manager is training an Adjunct Operations Supervisor as his deputy. It is of crucial importance that this trainee will assimilate the ongoing organisational safety conversation over the next couple of years.

For the rest of the organisation, it might be recommended to redesign a ‘Safety Behaviour Programme’, similar to the one ZPT employees attended in 2004. This programme apparently made a massive impact on the employees’ safety awareness. Having a regular refresher of this programme might give all ZPT staff an extra boost for further improvement of their safety dialogue based on clear, collaborative, and forward-looking leadership (Gassco, 2013).

6.6.2 Recommendations for the industry

Based on my personal experiences as a risk and crisis management consultant in organisations managing high-risk processes, I predominantly encounter executive teams that are convinced of an informational approach on communication. Based on the findings of this research, I will argue that this is only a part of an approach to collectively maintain safe operations in these types of organisations. Therefore it would be recommended to create and support a safety culture based on an open safety dialogue concerning the HRO principles as presented by Weick and Sutcliffe (2007), while being vigilant to plan, design, install, and disseminated rigorous and tested safety procedures and guidelines. A culture that encourages an open safety dialogue has to be supported by the management team, in which they challenge staff to be preoccupied with failure, support critical thinking that is reluctant to simplify, give deference to expertise in the organisation, and through leading by example.

6.7 Recommendations for further research

This research project indicates how a constitutive form of communication that underpins coordinated safety behaviour is viable on the sole condition that existing procedures and guidelines are disseminated and known. Therefore it would be highly recommended to examine the most favourable balance between both forms of communication, the informational and the constitutional, for maintaining safe operations in HROs.

As mentioned earlier in the limitations section, the findings of this research are not necessarily replicable to other similar organisation as the research was done in a small division of an international company. Therefore it would be worthwhile to expand this current research to large size HROs in multiple sectors. One of the starting points might be to examine whether this coordinated safety behaviour, based on a constitutive form of communication, is the same at Gassco's Headquarters in Norway. According to multiple interviewees at ZPT, this 'safety dialogue' as they call it, is represented even stronger in Norway than in any other affiliate of the company.

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Zoller, H. M., Fairhurst, G. T. (2007). Resistance leadership: The overlooked potential in critical organization and leadership studies. *Human Relations, 60*(9), 1331-1360.

APPENDICES

Appendix A List of secondary sources of published academic research and practitioner-oriented insights and data

Author(s)	Title	Year	Publisher
Breakwell, G. M.	The psychology of risk	2007	Cambridge University Press
Daiton, M., Zelley, E. D.	Applying communication theory for professional life - A Practical Introduction - Second Edition	2011	Sage Publications
Groeneweg, J.	Controlling the controllable - Preventing business upsets - Fifth Edition	2002	Global Safety Group Publications
Hübner, H.	The communicating company: Towards an alternative theory of corporate communication	2007	Physica-Verlag, Heidelberg
Marynissen, H., Pieters, S., Van Dorpe, S., van het Erve, A., Vergeer, F.	Geen commentaar! Communicatie in turbulente tijden (No comment! Communication in times of turbulence)	2010	Houtekiet / BusinessContact, Antwerp – Amsterdam
Morgan, M. G., Fischhoff, B., Bostrom, A., Atman, C. J.	Risk communication. A mental models approach	2002	Cambridge University Press
Perrow, C.	Normal Accidents - Living with high-risk technologies	1999	Princeton University Press, N.J.
Reason, J.	Managing the risks of organizational accidents	1997	Ashgate, UK
Regtvoort, F., Siepel, H.	Risico & crisiscommunicatie. Succesfactor in crisissituaties (Risk & Crisis communication. Success factor in crisis situations)	2007	Coutinho, Amsterdam
Slovic, P.	The perception of risk	2000	Earthscan Publications, UK
Slovic, P.	The feeling of risk. New Perspectives on risk perception	2010	Earthscan Publications, UK
Waring, A., Glendon, A. I.	Managing risk - Critical issues for survival and success into the 21st century	1998	Thomson
Weick, K. E.	Making sense of the organization	2001	Blackwell Publishing, UK
Weick, K. E., Sutcliffe, K. M.	Managing the unexpected. Resilient performance in an age of uncertainty	2007	John Wiley & Sons

Appendix B List of academic journals

Journal	Rating(*)
Academy of Management Journal	4
Academy of Management Review	4
Accident Analysis and Prevention	none
Applied and Preventive Psychology	none
Ergonomics	none
Group and Organization Management	3
Human Relations	4
Journal of Applied Psychology	4
Journal of Business and Technical Communication	none
Journal of Contingencies and Crisis Management	1
Journal of Risk Research	none
Journal of Safety Research	none
Judgment and Decision Making	none
Management Science	4
Personnel Review	2
Risk Analysis	3
Safety Science	2
Work and Stress	2

(*)According to Journal Recommendations for Academic Publications, Cranfield University SoM, Eighth Edition, April 2011

Appendix C Selected papers for systematic review

Year	Author(s)	Title	Publication	*
1992	S. B. Sitkin & A. L. Pablo	Reconceptualizing the determinants of risk behavior	Academy of Management Review	4
1995	R. L. Klein, G. A. Bigley & K. H Roberts	Organizational culture in high reliability organizations: An extension	Human Relations	4
1995	S. B. Sitkin & L. R. Weingart	Determinants of risky decision-making bahavior: A test of the mediating role of risk perceptions and propensity	Academy of Management Journal	4
1996	B. A. Sauer	Communicating risk in a cross-cultural context: A cross-cultural comparison of rhetorical and social understanding in US and British mine safety training programs	Journal of Business and Technical Communication	
1999	G. I. Rochlin	Safe operation as a social construct	Ergonomics	
2000	G. Grote & C. Künzler	Diagnosis of safety culture in safety management audits	Safety Science	2
2000	S. M. Houghton, M. Simon, K. Aquino & C. B. Goldberg	No safety in numbers: Persistence of biases and their effects on team risk perception and team decision making	Group and Organization Management	3
2001	E. S. Geller	Behavior-based safety in industry: Realizing the large-scale potential of psychology to promote human welfare	Applied and Preventive Psychology	
2001	J. Harvey, H. Bolam, D. Gregory & G. Erdos	The effectiveness of training to change safety culture and attitudes within a highly regulated environment	Personnel Review	2
2002	J. Harvey, G. Erdos, H. Bolam, M. A. A. Cox, J. N. P. Kennedy & D. T. Gregory	An analysis of safety culture attitudes in a highly regulated environment	Work and Stress	2
2005	A. Zacharatos, J. Barling & R. D. Iverson	High-performance work systems and occupational safety	Journal of Applied Psychology	4
2006	C. Burns, K. Mearns, P. McGeorge	Explicit and implicit trust within safety culture	Risk Analysis	3
2006	S. M. Conchie & I. J. Donald	The role of distrust in offshore safety performance	Risk Analysis	3
2006	S. M. Conchie, I. J. Donald & Paul J. J. Taylor	Trust: Missing piece(s) in the safety puzzle	Risk Analysis	3
2006	J. H. Michael, Z. G. Guo, J. K. Wiedenbeck & C. D. Ray	Production supervisor impacts on subordinates' safety outcomes: An investigation of leader-member exchange and safety communication	Journal of Safety Research	
2006	M. Specht, F. R. Chevreau & C. Denis-Rémis	Dedicating management to cultural processes: Toward a human risk management system	Journal of Risk Research	
2008	S. M. Conchie & C. Burns	Trust and risk communication in high-risk organizations: A test of principles from social risk research	Risk Analysis	3
2008	R. L. Dillon & C. H. Tinsley	How near-misses influence decision making under risk: A missed opportunity for learning	Management Science	4
2008	Y. Ganzach, S. Ellis, A. Pazy & T. Ricci-Siag	On the perception and operationalization of risk perception	Judgment and Decision Making Journal	
2008	T.-O. Nævestad	Safety cultural preconditions for organizational learning in high-risk organizations	Journal of Contingencies and Crisis Management	1
2009	S. M. Conchie & C. Burns	Improving occupational safety: using a trusted information source to communicate about risk	Journal of Risk Research	
2009	D. A. Lombardi, S. K. Verma, M. J. Brennan & M. J. Perry	Factors influencing worker use of personal protective eyewear	Accident Analysis and Prevention	
2009	T.-O. Nævestad	Mapping research on culture and safety in high-risk organizations: Arguments for a sociotechnical understanding of safety culture	Journal of Contingencies and Crisis Management	1
2010	J. M. Beus, S. C. Payne, M. E. Bergman & W. Arthur Jr.	Safety climate and injuries: An examination of theoretical and empirical relationships	Journal of Applied Psychology	4
2010	L. M. Kath, K. M. Marks & J. Ranney	Safety climate dimensions, leader–member exchange, and organizational support as predictors of upward safety communication in a sample of rail industry workers	Safety Science	2
2011	R. Hambach, P. Mairiaux, G. François, L. Braeckman, A. Balsat, G. Van Hal, C. Vandoorne, P. Van Royen & M. van Sprundel	Workers' perception of chemical risks: A focus group study	Risk Analysis	3

Appendix D Quality appraisal applied to research papers

Author(s)	Title	Publication	Year	Context or Industry	Key findings	Method of data collection	Method of data analysis	Theory	Literature review	Method	Integration	Contribution
Klein et al.	Organizational culture in high reliability organizations: An extension	Human Relations	1995	Air traffic control center and a nuclear power plant in the USA	The paper supports Schulman's theoretical typology of HROs	Quantitative, supported by field observations	Factor analysis & observations	In order to illustrate cultural similarities between HROs and other organizations, the author also elaborates on Schulman's theoretical typology of HROs	The paper cites appropriate literature and provides proper credit to existing work on the topic. The method chosen (case research (Cooke and Rousseau, 1988) to compare the data between HROs and other organisations.	Case study at FAA and nuclear power plant in the USA. Combination of quantitative (survey) and qualitative (field observation) methods were used with a representative amount of respondents and response rate.	The study provides a good test of the theory and offers sufficient empirical grounds for adding on to the existing theory. The method chosen (both qualitative and quantitative) is appropriate for the research question at hand.	This paper supports the assumption that there is a difference between HROs and other organizations. Furthermore it also supports Schulman's (1993) findings for a differentiation between an holistic and a decomponsable HRO.
Sitkin and Weingart	Determinants of risky decision-making behavior: A test of the mediating role of risk perceptions and propensity	Academy of Management Journal	1995	Not specified	Risk propensity an risk perception mediate the effects of problem framing and outcome history on risky decision-making behaviour	Quantitative - Study 1: MBA students. Study 2: Undergraduate students	Falsification/confirmation of hypothesis based on existing research about decision-making	The authors test and present a revised model of risk decision-making behaviour. By doing so, the study improves my understanding of the theory while mainly explaining the major concepts of this model.	Extensive review of the literature, and integration of previous knowledge and findings.	Research based, where the subjects (in Study 1 Master students and in Study 2 undergraduates) received a scenario and completed questionnaires. The procedures are used correctly and appropriately, and the major assumptions of the statistical techniques are well met.	The authors reduced the number of individual antecedent variables that influences the key mediators risk perception and propensity in order to fit the design of the studies. This is contradictory to their original paper (Sitkin & Pablo, 1992) stating that "single, isolated variables rarely influence behaviour do not reflect the complexity of life"	The paper makes a meaningful contribution to the literature in terms of theory and empirical knowledge.
Sauer	Communicating risk in a cross-cultural context. A study of rhetorical and social understanding in US and British mine safety training programs	Journal of Business and Technical Communication	1996	Mining industry in US and UK	Political knowledge and local experience influence how writers interpret and apply safety training in the workplace. Expert knowledge must be excluded from trainings.	Qualitative, but no explanation of the methodology	Analysis of printed communications (safety manuals and illustrations), however the used methodology it is not clear	The paper expands upon previous theory of cross-cultural communication by using rhetorical theory in the specific context. In that perspective it contributes to the knowledge about the relationship between risk communication and risk behaviour in cross-cultural settings. Unfortunately, major concepts are not elaborated, explained or put in perspective.	The author extensively cites governmental documents, books in the field of linguistics and communication, and own research papers. Therefore the understanding of the author's arguments are rather weak.	The author analyses texts, written by safety managers in US and UK coal mines. The used methods and procedures way the technical problems of representing safety information, the translation problem vis-à-vis cultural differences, and the political and ethical problem of defining a basis for agreement what constitutes safety.	The study doesn't provide a good test of the theory, nor sufficient empirical grounds for adding on to the existing theory. Although the author qualitatively examined strategies writers employ to represent expert knowledge about risk, the findings make no significant empirical research.	Although this paper doesn't make a new contribution to the literature in terms of theory and empirical knowledge, safety management practice, i.e. how to avoid generalized models of communication practice when it comes to communicating risk.
Grote and Künzler	Diagnosis of safety culture in safety management audits	Safety Science	2000	Petrochemical industry in US and UK	Analysing response patterns of different occupational, hierarchical and organisational groups in a company, in combination with meetings with focus groups on the feedback meetings can help to get a deeper understanding of safety management and safety culture	Quantitative questionnaires, supported by feedback meetings on the results of the survey	Factor analysis and evaluation of official safety audit reports	The paper applies aspects of the sociotechnical systems approach to get an understanding of safety culture and the role of perceptions regarding safety and proposes a method for diagnosis in plants. This study improves my understanding of this theory and an approach to diagnose safety management practices.	The paper cites appropriate literature and provides proper credit to existing work on the topic	The sample, measure, method, and observations ensure internal and external validity. The statistical procedures are used correctly and appropriately, and the major assumptions of the statistical techniques are well met.	The study provides a good test of the theory and offers sufficient empirical grounds for adding on to the existing theory. The authors discuss the need for a more process oriented approach to find indicators of safe behaviour and attitudes.	The paper makes a meaningful contribution to the literature in terms of theory, empirical knowledge, and management practice.
Houghton et al.	No safety in numbers: Persistence of biases and their effects on team risk perception and team decision making	Group and Organization Management	2000	Not specified	This study indicates that the law of small numbers bias and illusion of control decrease the risk perception of individuals and teams. The law of small numbers had a significant greater effect on team risk perception than on individual risk perception	Quantitative questionnaires	Individual and team based surveys among MBA-students, based on a 4 task case study	The paper extend theory to the relationship between biases, risk perception, and decision making. The theoretical basis is reinforced by prior research in this area.	The paper cites appropriate literature and provides proper credit to existing work on the topic.	Quantitative study among MBA-students from five different classes at a US state university. The sample, measures, methods, and procedures ensure internal and external validity.	The study provides a good test of the theory and hypotheses, and offers sufficient empirical grounds for counting existing theory.	The paper counters the recommendations of some scholars who suggested that adding people to a group process is likely to protect agains biases.
Harvey et al.	The effectiveness of training to change safety culture attitudes within a highly regulated environment	Personnel Review	2001	Nuclear processing plant in the UK	This study shows that safety trainings have a significant impact predominantly for management, not for shop floor employees	Quantitative questionnaires	Survey of 60 Likert-style items (6 answer points), conducted on two occasions, 18 months apart	The paper tests the impact of training to change in safety culture, attitudes and perception in nuclear power plants in the UK.	The paper offers extensive insights in the literature on risk taking, risk perception, and safety culture.	The large sample participated in the quantitative survey ensure internal and external validity. The statistical procedures are used correctly and the major assumptions of the statistical techniques are well met.	The study provides a good test of the theory and hypotheses, and offers sufficient empirical grounds for adding on to the existing theory. No explanation could be raised about the method chosen. As the authors indicate that risk may be as (a) partly socially constructed, (b) relatively stable and (c) measurable, this method has been appropriate to combine quantitative research methods with qualitative research.	This paper makes a meaningful contribution to the literature in terms of both empirical knowledge and management practice.
Harvey et al.	An analysis of safety culture attitudes in a highly regulated environment	Work and Stress	2002	Nuclear processing plant in the UK	The conclusion of this study is that there are two or more safety cultures in an organisation. In this case, three cultures were found among three occupational groups	Quantitative questionnaires	Survey of 60 Likert-style items (6 answer points), conducted in 2 UK plants	Good analysis of safety culture, safety values, and the fact that culture can differ among teams in one organisation. Link to communications and leadership styles.	The paper cites relevant literature and provides proper credit to existing work on the topic	The sample, measures, methods, observations, procedures, and statistical analyses all ensure internal and external validity.	This study provides a good test of the theory and the hypotheses, and sufficient empirical grounds for adding on to existing theory.	The paper makes a new and meaningful contribution to the literature in terms of theory and empirical knowledge.
Zacharatos et al.	High-performance work systems and occupational safety	Journal of Applied Psychology	2005	Canadian manufacturing organisations + telecom and petroleum industry	Trust in management and perceived safety climate are found to mediate the relationship between high-performance work systems and safety performance, measured in terms of personal safety orientation and safety participation	Quantitative questionnaires	Survey among HR practitioners (study 1) between high-performance work systems and occupational safety. Major concepts are clearly elaborated and explained.	The paper investigates the relationship between high-performance work systems and occupational safety. Major concepts are clearly elaborated and explained.	The paper cites relevant and excellent literature and provides proper credit to existing work on the topic	Research based on to studies: in Study 1, data was obtained from company human resource and safety directors (n=83), and from employees (n=1,845) in 2 manufacturing plants. Study 2 used data from 189 front-line employees in 2 organizations.	These 2 quantitative studies provide confirmation of the important role organizational factors play in ensuring worker safety	This study indicates mechanisms (i.e.: safety knowledge, safety motivation, safety compliance, and safety initiative) through which high-performance work practices (i.e. flexible staffing, first aid and near misses) about the relationship between risk communication
Burns et al.	Explicit and implicit trust within safety culture	Risk Analysis	2006	UK gas plant	Explicit and implicit trust are found to be separate constructs. Workers expresses explicit trust for their workmates, supervisors and senior managers, but only implicit trust for their workmates.	Quantitative questionnaire and priming task	One-on-one meetings with participants in a private room, conducted by a researcher	The article proposes a model that conceptualizes explicit trust as part of the surface levels of safety culture and implicit trust as part of the deeper levels of safety culture.	The paper doesn't make full use of the existing literature in the fields of trust, risk perception, and safety behaviour.	The authors tested their research on a priming task. The procedures are correctly used, and the major assumptions of the statistical techniques are well met. 53 employees (+/- 50% of the workforce) participated in the study.	The study provides a good test of the hypotheses, and empirical grounds for adding on to existing theory. The priming test is a good method to evaluate the existing safety culture (that was part of the research objective).	The article contributes to present a model of trust within safety culture, unfortunately they don't. However, the paper makes an interesting contribution to the existing literature in terms of management practice.
Conchie and Donald	The role of distrust in offshore safety performance	Risk Analysis	2006	UK offshore gas plant	Attitudes toward offshore management were found the strongest predictor of safety performance at an individual level. At a team level, the safety climate variance was predicted by attitudes toward contractors and workmates.	Quantitative survey	logistic regression analysis	The paper test theory to the relationship between trust and risk perception. Major concepts are clearly elaborated and explained.	The paper cites appropriate literature in the fields of trust, risk perception, and safety behaviour.	This procedure of the study don't fully ensure external validity; the questionnaires were distributed by offshore officers ,and after three weeks collected by the same officers. Therefore, no proper explanation or guidelines could were given to the participants.	The method chosen (quantitative) is not really in line with the nature of trust.	Although the design of the research is discussable, it is the first study that examines the role of distrust on safety behaviour.
Michael et al.	Production supervisor impacts on subordinates' safety outcomes: An investigation of leader-member exchange and safety communication	Journal of Safety Research	2006	Wood products manufacturing facilities in the USA	The influence of leader-member exchange is greater than that of safety-related events. Also employee perceptions of safety knowledge have safety implications.	Quantitative survey	598 workers participated in a survey based on LMX, safety communication, job satisfaction and safety-related events.	Research based on the LMX theory as presented by Gean & Uhl-Bien (1995) to study the relationship between LMX and safety communication.	Good citation of the literature on LMX and proper credit to existing work in the field, but poor referencing to literature in the field of risk and safety communication.	Participation employees at five wood manufacturers completed a survey during their work shift. This resulted in data on LMX, safety communication, and safety-related events. Archival data on OSHA-recordables were also obtained from the producers' human resources databases.	The study provides a good test of the theory and offers sufficient empirical grounds for adding on to the existing theory in terms of safety communication and LMX.	Results from this study further emphasize the importance of production supervisors and illustrate the potential role of leader-member exchange in enhancing workplace safety.

Conchie and Burns	Trust and risk communication in high-risk organizations: A test of principles from social risk research	Risk Analysis	2008	Health (UK)	The increase in trust beliefs following open communication is weaker than the reduction in trust following a lack of communication.The level of trust developed through communication (or lack of) influenced the way that subsequent risk information was processed.	Quantitative servey of 393 student nurses	A mixed experimental survey design: based on between- and withi participants	The paper test the trust asymmetry principle, as described by Slovic (1993)	The paper cites appropriate literature.	I'm still surprised why researchers keep on testing typical social constructs such as communication and trust with quantitative methods.	An experimental survey of student nurses is not exactly an example of a HRO!	This study suggests that one way to increase trust within high-risk organizations is through open communication.
Dillon and Tinsley	How near-misses influence decision making under risk: A missed opportunity for learning	Management Science	2008	NASA (US)	Near-misses are perceived as successes, and this information leads people to choose a riskier alternative because of a lower perceived risk following near-miss events.	Quantitative servey among students and NASA staff based on a fictive scenario	Correlation analysis of the data.	This paper extend theory to the relationship between risk communication and perception in a meaningful way. It explains why organisations don't learn from near-misses.	Good citation of appropriate literature and proper credit to existing work in the field.	Quantitative research, correctly applied and major assumptions of the statistical techniques are reasonably well met.	This paper makes a nice synthesis of the link between formal and informal communication and risk perception, and why this often fails in organisations.	The paper makes a meaningful contribution to the literature in terms of empirical knowledge and management practice.
Conchie and Burns	Improving occupational safety: using a trusted information source to communicate about risk	Journal of Risk Research	2009	One single UK construction site	Trust in information from the project manager, safety manager, UK HSE and workmates is based on the source's accuracy, while trust in information from supervisors is based on their demonstrations of care. The UK HSE and safety manager emerged as the most trusted sources and the most influential in shaping workers' risk-related behavioural intentions.	Quantitative servey based on Likert-type questionnaire	Coding of data on a six-point scale, with each point increasing by increments of 20%	The study is based on existing theory in the field of trust, trustworthiness, and trust in information sources.	The paper doesn't make full use of the existing literature in the fields of trust, risk perception, and safety behaviour. However the dominant authors in the field are cited in order to underpin their claims.	Quantitative research among 131 workers from a single industrial construction site. The assumptions are statistically well examined and the conslucions well interpreted.	The study does not reveal big surprises; Mayer et al (1995) and Schoorman et al (2007) already indicated the factors of trustworthiness.	The results of this study can help organisations to design appropriate safety campaigns in terms of tone of voice and the sender of the message.
Lombardi et al.	Factors influencing worker use of personal protective eyewear	Accident Analysis and Prevention	2009	Manufacturing, construction, and service/retail industry in Massachusetts USA	Lack of comfort/fit, and fogging and scratching of the eyewear were suggested as the most important barriers to personal protective eyewear (PPE) usage. Younger age and lack of safety training were other important factors affecting use of PPE.	Qualitative research based on 7 focus groups	Not explained	The paper identifies and describes the factors that influence a workers' decision to wear personal protective eyewear and the barriers that exist in preventing their use.	Good citation of appropriate literature and proper credit to existing work in the field.	The study is based on a series of focus groups enrolled workers and supervisors primarily from manufacturing, construction, or service/retail industries that had potential exposure to eye injury hazards in their job tasks.	The study provides a good test of the theory and offers sufficient empirical grounds for adding on to existing theory. The method chosen (qualitative) is very appropriate for the research question and theory. However, they do not disclose the way in which the data were analysed.	Several potentially modifiable factors are identified that lead to an increase in workers' personal protective eyewear (PPE) use . In doing so, the paper makes a meaningful contribution to management practice.
Kath et al.	Safety climate dimensions, leader–member exchange, and organizational support as predictors of upward safety communication in a sample of rail industry workers	Safety Science	2010	Canadian Pacific Railway	The dominant factor predicting upward safety communication was perceived management attitudes toward safety, followed by job demands interfering with safety and then leader–member exchange.	Quantitative servey based on a five level Likert-type questionnaire	By applying dominance analysis of the data	The authors are building on existing theory in the fields of LMX, perceived organizational support, and safety climate to examine perceived management attitudes toward safety, job demands interfering with safety, and pressure from coworkers to behave safely.	The authors doesn't make full use of the existing literature in the fields of risk communication, risk perception, and safety behaviour.	The question coul be raised if a quantitative servey is the best guarantee for analysing collective constructed interpretations (i.e., safety climate, LMX, and organisational support) as predictors of upward safety communication?	The study provides a good test of the theory and offers sufficient empirical grounds for adding on to the existing theory. However the method chosen might be discussable whether it is appropriate for the research question.	Recommendation to encourage the dyadic relationships between employees and supervisors, instead of solely applying them to enhance safety policies and procedures.
Hambach et al.	Workers' perception of chemical risks: A focus group study	Risk Analysis	2011	Belgian chemical companies	This study suggests that training programs for prevention advisers should include topics such as understanding of workers' perceptions, usefulness of a participatory approach, and communication and education skills.	Qualitative research based on 7 focus groups with blue-collar workers	Not explained	The authors claim their research is based on grounde theory (GT), but they give no explanation of how GT was applied to the research design.	Little combine between literature, data, and experience, and no attention to subtleties of meaning. Ignoring of prior research in the literature	Qualitative study, but no transparency in the process. No insight in the way focus group members were selected, no explanation of how coding and conceptual labelling was done	Right method for this research, but more group perceptions and less individual perceptions. Therefore individual interviews could have improved the findings and recommandations	This is the only paper that covers my research-question, but unfortunately not in an appropriate way.

Appendix E Example of grid document

Date: 10-apr-12 **Interviewee:** #14 **Interviewer:**HM **Purpose:** P2
Start: 11.05 **Finish:** 12.00 **Observer:** ES
RQ: *Can you name 3 risks at Gassco with high consequences, and 3 risks with low consequences?*
Order of personal elements: 5, 1, 6, 4, 3, 2

#	Construct	1 Gas leak	2 Serious personal accident	3 Lost of communication between ZB - DK	4 Contamination in the production process	5 Gas fire	6 Major Accident Potential	Construct pole
1	Technical failure	*4	*4	*2	1	4	3	Human failure
2	100% measurable and controllable	4	4	1	*2	*5	*2	Not measurable and controllable at all
3	100% gas related	*1	*4	5	*2	1	2	Nothing to do with gas
4	No material damage	*4	2	*1	3	*5	4	Major material damage
5	No link with the design of the plant	*2	3	5	*4	2	*4	Linked to the design of the plant
6	No personal injuries	3	*5	*1	2	*4	2	Manjor personal injuries
7	No damage to image	5	2	*3	*1	5	*5	Major image damage
8	Factors external to pipe system	*1	3	2	4	*1	*5	Factors directly linked to pipe system

Appendix F Overview of risk elements

Risk types (8)	Risk groups (42)	Risks (168)	
Fires & leaks	Explosion	Explosion	Outburst
		Gas explosion	
	Gas leak	Gas leak	Containment of gas
		High pressure gas leak	Complete rupture
		Gas leak in pipe line	Escape of gas
		Gas leak (not ignited)	Gas leak at terminal
		Gas leak in train nr. 1	Major gas leak
		Leak	
	Minor gas leak	Minor leaks	Minimal gas leak
		Small gas leak	
	Gas fire	Fire	(Gas) fire
		Gas fire	
		Fire in process area	
	Fire (not linked to gas)	Fire	Electrical fire
		Fire (general)	Minor fire
	Damage onshore pipeline	Damage onshore pipeline	
	Domino effects	Domino effects	
Injuries & illness	Maintenance on plant	Labour in pit	Labour using heat sources on plant
		Maintenance back-up electricity group	
		A piece that needs to be maintained, but not free of gas	
	Contractors	Contractors	Accident with contractor
		Contractor not wearing personal protection	
		Contractors neglecting safety rules	
		Vehicle on the plant	
	Personal Protection Systems (PPS)	Cut wounds	Minor eye injury
		Working without gloves	
		Not wearing appropriate gloves	
		Not wearing protection clothes	
	Sickness	Illness	Sickness operator
		Staff's well-being	
		Sickness staff	
	Human error with physical consequences	Someone hurts him/herself	To fall
		Stumbling danger	Personal accident
		Bruises	Burn
		Electrocution	Falling from scaffolding
		Small personal injuries	
		Serious personal accident	
		Badly stored items	
	Death	Deadly accident	
Emissions	Chemical incident	Leak in water glycol system	Working with chemicals
		Inerting' with nitrogen	Contamination in the system
		Water Glycol leak	
		Glycol leak	
	Noise pollution	Noise pollution	
Criminal acts	Criminal acts	Terrorism	Burglary
		Bomb warning	Letter bomb
		Hacker	Attack
		Hacking of leased lines ZB-DT	
		External threat (Terrorism)	
	Financial	Financial	Bribary

External factors	Image	Bad publicity
	Closing down plant	Closing down plant
	Airplane crash	Airplane crash
Facilitating systems	Equipment	Inspection of equipment Mal-functioning chromatographs Broken air compressor Us of ladders Ordering tools without valid certifications Mal-use of equipment Working with non-approved equipment/tools
	Access	Access badges Access Dunkirk (DTDA)
	Technical problems with IT/non operating systems	HVAC offices (=airco) LAN rupture Cooler failure Electricity rupture Electricity black-out (no operations possible) Heavy PCDA problems (=computer screens) Lost of communication between ZPT and DTA Black-out of crucial systems Rupture of telephone lines Heating of server room
	Banalities	Broken chair in the meeting room Broken coffee machine
	Maintenance	Drainage of metering tubes
Gassco specific process	Pressure in pipe system	Pressure in pipeline Differences in pressure in tubes Making the terminal pressure free
	Mechanical problem	Mechanical problem Malfuctionings Mechanical defect
	Technical error on installation	Technical errors
	False alarm	False alarm False process shut down
	Failure of safety systems	Fire water Black-out safety systems Testing smoke alarms
	Failure of process systems	Rupture of safety electric group Rupture DCS (controle system) Redundant equipment failure Meters vent-installation Unplanned shutdown
	Quality Control	No follow-up of gas quality Contamination in gas
	Problems with pipes	Major Accident Potential
Behavioural issues	Work permits contractors	No timely execution of work orders on utilities No follow-up of work permits No returned work permits Processing of work permits Working without a work permit
	No response to alarms	No response to alarms
	Strikes	Strikes
	Lack of experience	Lack of experience among new employees
	Safety on excursions	Safety on excursions
	Human error with technical consequences	Minor accident
	No timely reporting of malfunctionings	No execution of preventive maintenance + fieldlogging OPS
	Not acting according procedures	Not acting according procedures Unsafe operations
	Bad communication	Bad communication

Appendix G Overview of constructs

Construct types (7)	Construct groups (36)	Construct left	Construct right
Tangible & non tangible damage	Image & media	No reputational damage	Major reputational damage
		No media-impact / awareness	Major media-impact / awareness
		No image damage	Major image damage
		No media-attention	Lots of media-attention (front-page news)
		Reputational damage	No impact on reputation
Tangible & non tangible damage	Environment	Low impact on environment	Major impact on environment
		No danger for the environment	Danger for the environment is massive
		Very dangerous products involved	No dangerous products involved
		No impact on environment	Causes environmental damage
		No impact on environment	Impact on environment
		No impact on environment	Maximal impact on environment (environmental disaster)
		No impact on environment	100% environmental impact
		No impact on environment	Major impact on environment
		No impact on environment	Impact on environment
		Nothing to do with chemical substances	100% linked to chemical substances
		No ecological impact	High ecological impact
		No environmental impact	Major environmental impact
Tangible & non tangible damage	Material damage	No damage on installation	Major damage on installation
		Minimal damage	Maximal damage
		No material damage	Large material damage
		No material damage	Lots of material damage
		The installation continious its production	Complete shut down of installation
		No damage of installation	Damage of installation
Tangible & non tangible damage	Duration of consequences	Consequences on short term	Consequences on the long term
		Can be quickly fixed	It takes a while to fix it
Tangible & non tangible damage	Clients	Little economical impact (damage) for Gassco & clients	Major economical impact (damage) for Gassco & clients
		No impact on supply to clients	Supply to clients stops
		No impact on supply to clients	Major impact on supply to clients
Tangible & non tangible damage	Financial impact	Low financial impact	High financial impact
		Low costs	High costs
		Little financial damage	Large financial damage
		No financial lost	Financial lost
		No economical impact	Major economical impact
Tangible & non tangible damage	Scale of impact	The consequences are minimal (can be fixed))	The consequences are disastrous
		Minimal impact	Large scale impact
		Minimal consequences for ZPT	Major consequences for ZPT
		It is really bad	It looks worser than it really is
		No impact on Gassco	Major impact on Gassco
		Minimal consequences for ZPT	Large consequences for ZPT
		Impact on the entire organisation	No impact at all on the organisation
		Potential consequences are small	Potential consequences are large
Plant & process related	Production process	The consequences on production are small	The consequences on production are large
		No operational consequences	Massive operational consequences
		100% linked to the production process on the plant	Nothing to do with the production process on the plant
		No lost of production	Major lost of production
		No impact on production	Massive impact on production
		No operational consequences	Lots of operational consequences
		Production will never stop	Production wil definitely stops
		Production is not involved	Production stops
		No impact on production	Production stops
		No impact on systems	The system brakes down
		Nothing to do with our installation	Everything to do with the installation
		No impact on continuity of the plant	The plant is out
		Production continious	Production stops
		No impact on production	Major impact on production
Plant & process related	Gas related	Gas related	Not gas related
		Linked to gas	Not linked to gas
		Has something to do with gas	Has nothing to do with gas
		Not gas related	Entirely gas related
		100% related to gas	Has nothing to do with gas
Plant & process related	Pipe pressure	Doesn't lead to a high pressure gas leak	Definitely leads to a high pressure gas leak
		Not related to pressure	Pressure related
Plant & process related	Physical location	Inside the control room	Outside the control room
		Independent of location	Dependent of location
		Has in every aspect to do with the plant	Has nothing to do with the plant
		Happens outside the process area	Happens inside the process area
		Has nothing to do with the design of the plant	Has to do with the design of the plant
		Happens on the plant	Happens in the building

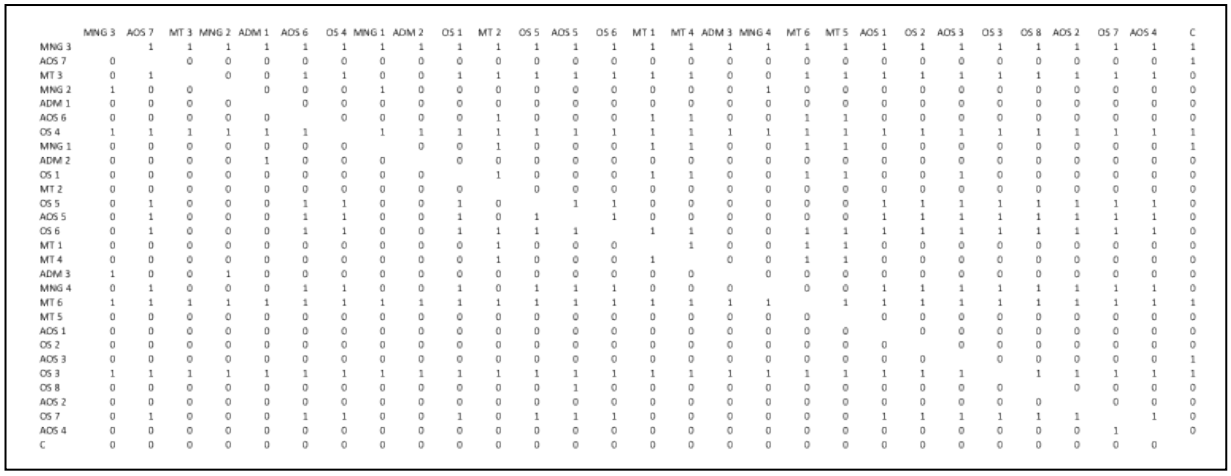
Outcome probability	Internal or external consequences	The outside world is not affraid	The outside world is definitely affraid
		Major consequences for the neighbourhood	Minor consequences for the neighbourhood
		Impact solely on ZPT	Impact on neighbouring companies
		No danger for neighbouring companies	Danger for neighbouring companies is large
		Doesn't activate an incident immediately (fire / explosion	Immediately activates an incident (fire / explosion)
		Might lead to fire	Will never lead to fire
		Doesn't lead to an explosion	Will certainly lead to an explosion
		Has nothing to do with fire	Has definitely to do with fire
		Doesn't lead to an accident	Will definitely lead to an accident
Outcome probability	Probability	The chance it happens is non existing	The chance it happens is certain
		The impact of the risk is quasi non existent (neglectable)	The impact of the risk is very large (100%)
		Certain risk	Uncertain risk
		The chance it happens is high, consequences are low	The chance it happens is small, consequences are high
		Chance there will be a fire is 0%	Chance there will be a fire is 100%
		The chance an accident will happen is zero	100% certainty an accident will occur
		It never occured to Gassco	It already happened to Gassco
		It seldom happens	It fequently happens
		0% chance it will happen	The chance it happens is real
Non human root causes	Internal or external cause	Happens outside our will (little influence on Gassco)	Happens among us (large influence on Gassco)
		External factor that leads to a crisis is non-existant	External factor that leads to a crisis is 100% certain
		Root cause is outside Gassco	Root cause is inside Gassco
		External cause	Internal cause
		No physical presence	Physical presence
		External factors	Internal factors
		Unknown	Known
		Danger is inside Gassco	Danger is outside Gassco
		Internal root cause	External root cause
Non human root causes	Work permits	No work permits required	Always work permits required
		Nothing to do with work permits	Everything to do with work permits
Non human root causes	Scale of situation	Safe situation (enough staff)	Risky situation
		Not really a dangerous situation	Definitely a dangerous situation
Non human root causes	Flaws, mechanical, electronics	Problems due to electronics	Mechanical problems
		Not related to defects	100% related to defects
Non human root causes	Various parameters	Products	Materials
		Has nothing to do with ladders	Has always to do with ladders
		Always fire-related	Always gas-related
		Factors external to pipelines	Factors inside the pipelines
		Nothing to do with cooling mechanisms	It has to do with cooling mechanisms
		Nothing to do with electricity	Exclusively to do with electricity
		Nothing to do with air	Exclusively to do with air
		No quality	Quality
		Silence	Extremely loud noice
		Nothing to do with heat	Exclusively to do with heat
		Nothing to do with leaks	Exclusively to do with leaks
		Nothing to do with fire	Exclusively to do with fire
Human factors	Experience	Experience will allert in time	No experience will not allert at all
		Gassco has nothing to learn	Gassco (still) has a lot to learn
		Routine	Experience does not sounds an alarm
Human factors	Human or technical error	Human error	Technical error
		Internal threat	External threat
		Human factor	Technical factor
		The risk is linked to processes	The risk is linkded to individuals
		No impact of a mechanical problem	Major impact of a mechanical problem
		100% computer driven	100% manual
		Technical error	Human error
		Human failure	No human failure
		Human cause	Technical cause
		No systems error	100% Systems error
		There are always humans involved	There are never humans involved
		No error made by staff	Error made by staff
		No human error	100% human error
Human factors	Material vs. Human consequences	Impact on the individual	Impact on the entire plant
		No consequences for humans and organisations	Destroys humans and installation
		Linked to tools	Personal injuries
Human factors	Physical damage to humans	Consequences on human level are little	Consequences on human level are severe
		No injuries	Heavy injuries (that might lead to dead)
		Might cause severe burns	Will not cause burns
		No damage to humans	Damage to humans
		No consequences for humans	Consequences for humans
		No victims	Many victims
		Potentially few (severe) victims	Potentially many (severe) victims
		No bruces and injuries	Many bruces and injuries
		Will lead to an accident with physical injuries	Doesn't lead to an accident with physical injuries

		Will lead to severe sickness	Will not lead to severe sickness
		Individual danger	Danger for the entire community
		No injuries	Heavy injuries
		No fractures	Many fractures
		No life-danger	You are dead for sure
		No impact on human damage	You will be dead
		Does not cause human suffer	Causes great human suffer
		No wounds	Severe wounds
		Causes no human suffering	Causes lots of human suffering
Human factors	Emotional impact to humans	Little impact on personal and social life	Major impact oon personal and social life
		Low individual stress level	High individual stress level (adrenaline takes it over)
		I will feel safe	I will feel unsafe
		Emotionally close to owv staff	This has no emotional bond with me
		Creates no stress for OPS and Maintenance	Creates a lot of stress for OPS and Maintenance
		Emotional vulnerable	No emotional vulnerability
		People won't worry	People will feel worried
		No impact on staff's safety feeling	Major impact on staff's safety feeling
		No stress	Collective stress
Human factors	Communication	Good communication can avoid problems	Communication doesn't help
		Has nothing to do with communication	Has to do with communication
		Has nothing to do with transfer of information	Has to do with transfer of information
Human factors	Intention	Accidential	Intentional (on purpose)
		By accident	On purpose
Organisational relation structures	Impact on my job	No impact on ZPT's existence	Existence ZPT stops
		No consequences for staff	High consequences for staff
		You can still do your job	You can't come to work
		No impact on staff's ergonomics	Major impact on staff's ergonomics
		Office work	Physical work
Organisational relation structures	Internal or external staff	Risk is among own staff	Risk is external (to staff)
		Own staff	External staff
Organisational relation structures	Alarming the hierarchy	Management will be alerted and will solve the problem	We will solve the problem
		It will not be reported to Norway	It will allways be reported to Norway
		No report to Norway	Always reported to Norway
		Doesn't have to be treated in synergie	Has to be treated in synergie
		No notification audit -> SMART	Notification audit -> SMART
Organisational relation structures	Operations vs. Management	Organisational problem	Production-technical problem
		Operations decides	Management decides
Organisational relation structures	Operations vs. Maintenance	Operations	Maintenance
Risk & crisis containment	Procedures	100% follow-up of procedures	No follow-up of procedures
		Strictly follow-up of procedures is required	Procedures are not absolutely not required
		100% prepared (we have a scenario)	We are not prepared (we have no scenario)
		Can be solved with procedures	Procedures won't help
		Not related to procedures	Totally related to procedures
		Concrete	Abstract
		No corrective intervention	Altijd correctieve interventie
		Has to do with not following procedures	Has nothing to do with procedures
		Following procedures	Not following procedures
		Has nothing to do with procedures	Has exclusively to do with procedures
		Has nothing to do with procedures	Has everything to do with procedures
Risk & crisis containment	Help required?	No external help required to solve the problem	External help required to solve the problem
		We can solve it	We can't solve it
		We can't intervene	Early intervention might prevent worser things
		Gassco will solve the problems	Emergency services will solve the problem
		We can solve it	We need external help to solve it
		Gassco can solve it	External help is required to get things under control
		We solve it (no help required)	The emergency services will be allerted
		We have to rely on contractors to solve it	No contractors required
		Police will be allerted	We don't call the police
		The public safety plan will not be activated	Full deployment of the public safety plan
		We solve it	Only third parties can solve this
Risk & crisis containment	Prevention	We can take precautionary measures	We can't take precautionary measures
		Preventive intervention is possible	Preventive intervention is not possible
		Planning can keep it under control	You can't plan this, it's out of control
		Awareness for prevention will lead to minor danger	No awareness for prevention will lead to severe danger
		Preventive testing	Execute
		You can protect yourself	You can't protect yourself
		Is avoidable	Is unavoidable
		No detection systems required	Detection system required for safe work conditions
		Nothing to do with safety behaviour	100% linked to safety behaviour

Risk & crisis containment	Control	Controllable	Definitely not controllable
		100% control of the risks	No control of the risks
		100% control	0% control
		We have a full and clear view on this	We have absolutely no clear view on this
		We fully control this	We have no control whatsoever
		The risks can be well assessed	We can't fully assess the risks
		As a company you can keep this under control	As a company you can't keep this under control
		Having a clear vier	You can't see anything
		100% measurable and under control	Not measurable nor under control
		Controlled	Not controlled
		Risk is well manageable	Risk is not manageable
		Nothing to do with lack of control	Lack of control
		Passive	Intervening actively
Risk & crisis containment	Escalation	Evolution of impact (can increase)	Impact is immediately maximal and not under control
		Kan escalate / evolve	Can not increase
		Processes in a sequence	Isolated processes
		No domino-effect	Domino-effect
		No impact on other systems	Major impact on other systemens
		Will lead to a domino-effect	Doesn't lead to a domino-effect
		Can not escalate	It wil escalate for sure

Appendix H Social network datasets

H.1 Question 1.1



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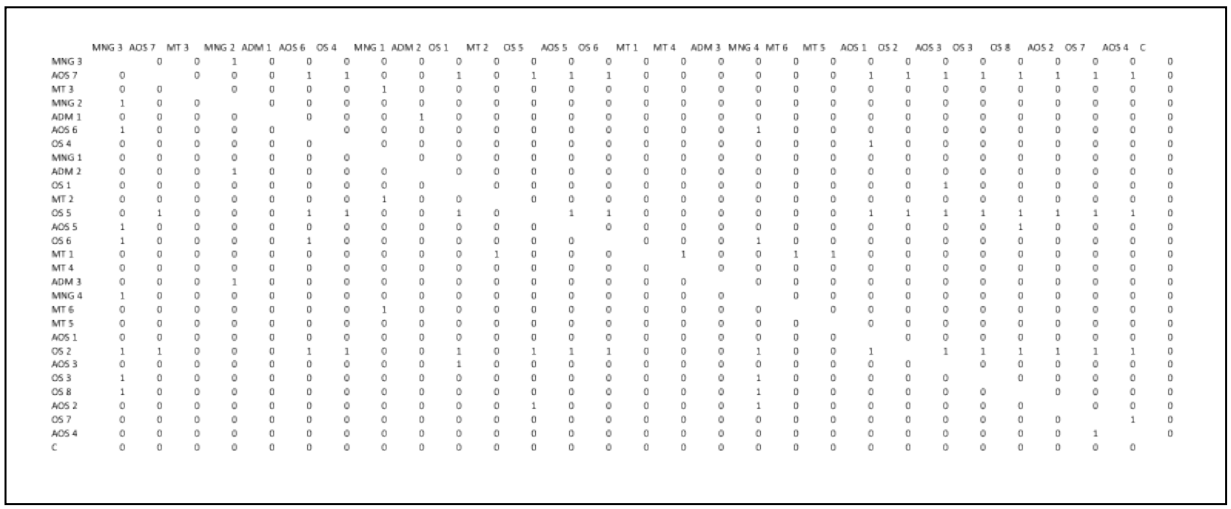
H.2 Question 1.2



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OS 4	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
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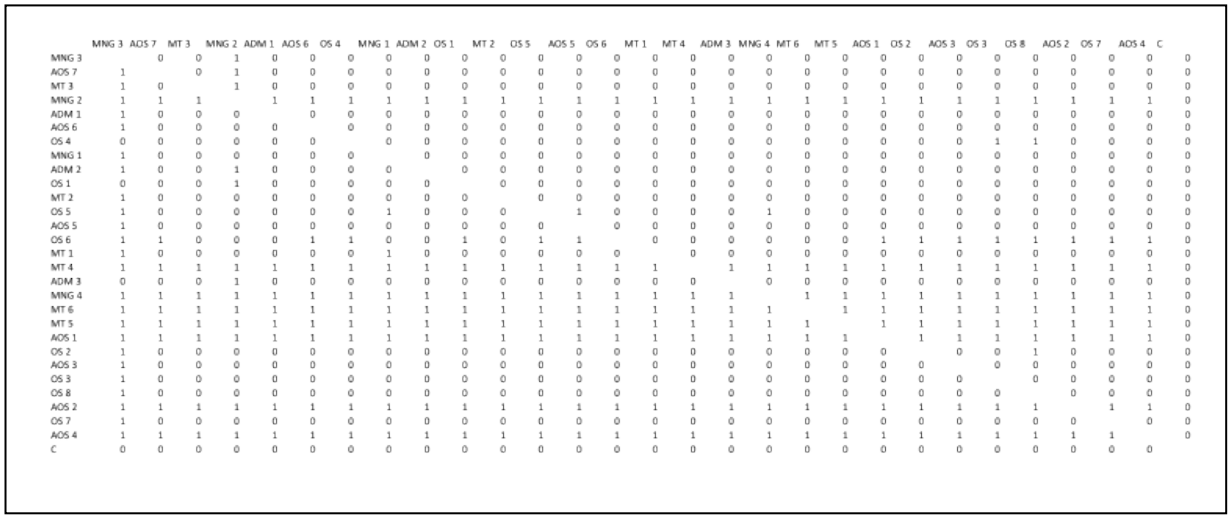
H.3 Question 2



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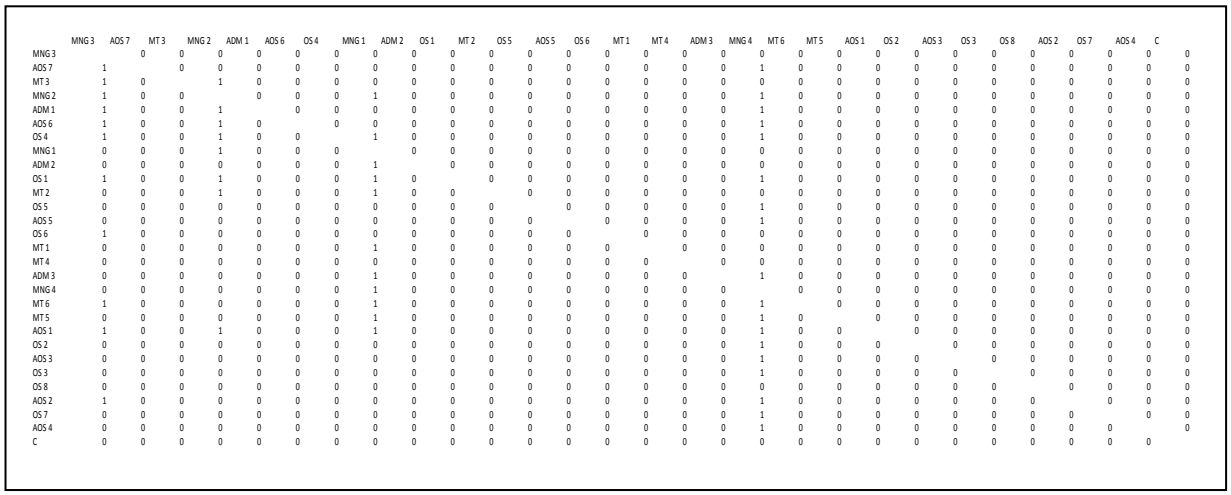
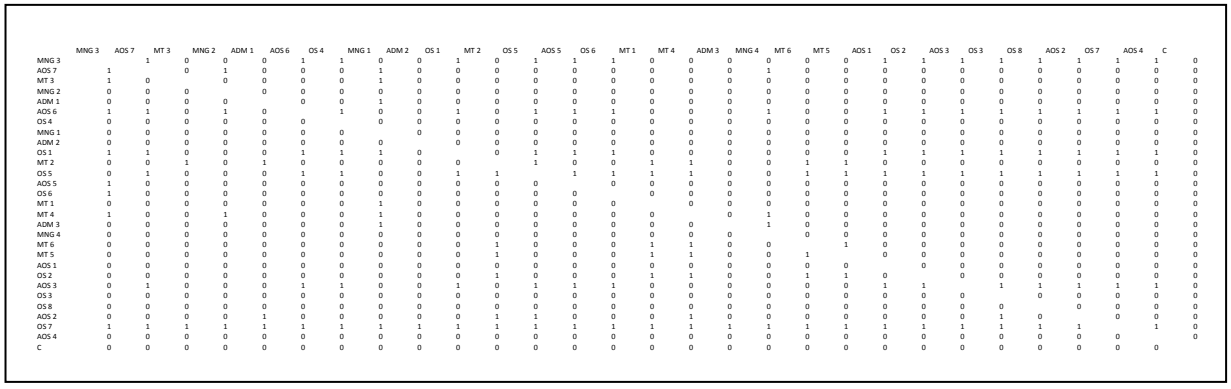
MT 3	1	0		1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MNG 2	1	1	1		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0
ADM 1	1	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AOS 6	1	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
OS 4	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0
MNG 1	1	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
ADM 2	1	0	0	1	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
OS 1	0	0	0	1	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MT 2	1	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
OS 5	1	0	0	0	0	0	0	1	0	0	0		1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
AOS 5	1	0	0	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
OS 6	1	1	0	0	0	1	1	0	0	1	0	1	1		0	0	0	0	0	0	1	1	1	1	1	1	1	1	0
MT 1	1	0	0	0	0	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0
MT 4	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1		1	1	1	1	1	1	1	1	1	1	1	1	0
ADM 3	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0
MNG 4	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1		1	1	1	1	1	1	1	1	1	1	0
MT 6	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1		1	1	1	1	1	1	1	1	1	0
MT 5	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1		1	1	1	1	1	1	1	1	0
AOS 1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1		1	1	1	1	1	1	1	0
OS 2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0	0	1	0	0	0	0
AOS 3	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0
OS 3	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0	0	0	0	0
OS 8	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0	0	0	0
AOS 2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1		1	1	0
OS 7	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0	0
AOS 4	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1		0
C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	

H.4 Question 3



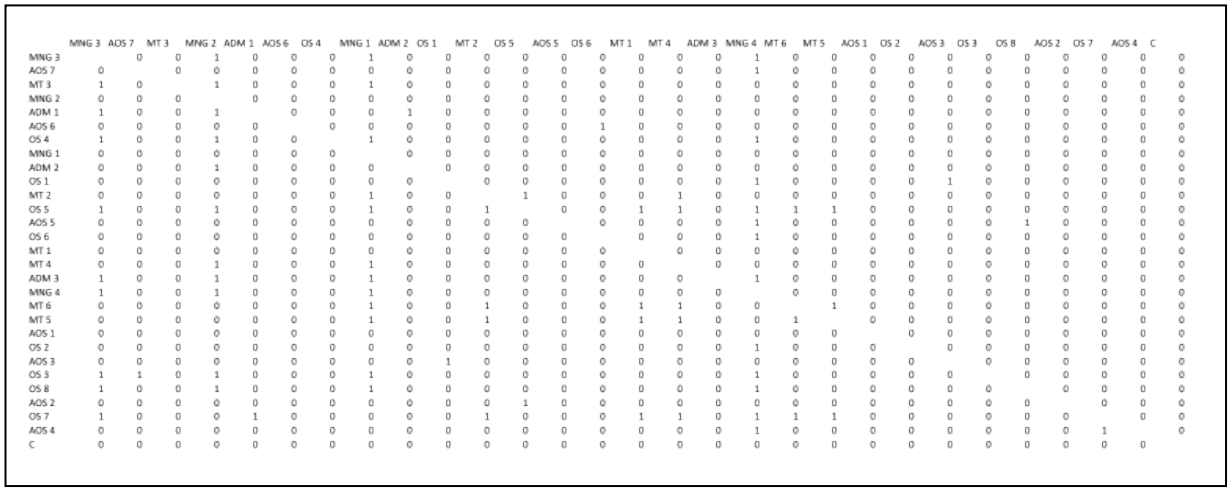
	MNG 3	AOS 7	MT 3	MNG 2	ADM 1	AOS 6	OS 4	MNG 1	ADM 2	OS 1	MT 2	OS 5	AOS 5	OS 6	MT 1	MT 4	ADM 3	MNG 4	MT 6	MT 5	AOS 1	OS 2	AOS 3	OS 3	OS 8	AOS 2	OS 7	AOS 4	C
MNG 3		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AOS 7	1		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
MT 3	1	0		1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MNG 2	1	0	0		0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
ADM 1	1	0	0	1		0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
AOS 6	1	0	0	1	0		0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
OS 4	1	0	0	1	0	0		1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
MNG 1	0	0	0	1	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
ADM 2	0	0	0	0	0	0	0	1		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
OS 1	1	0	0	1	0	0	0	1	0		0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
MT 2	0	0	0	1	0	0	0	1	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
OS 5	0	0	0	0	0	0	0	0	0	0	0		0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
AOS 5	0	0	0	0	0	0	0	0	0	0	0	0		0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
OS 6	1	0	0	0	0	0	0	0	0	0	0	0	0		0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
MT 1	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0
MT 4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0
ADM 3	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0		1	0	0	0	0	0	0	0	0	0	0	0
MNG 4	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0
MT 6	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1		0	0	0	0	0	0	0	0	0	0
MT 5	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0		0	0	0	0	0	0	0	0	0
AOS 1	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0		0	0	0	0	0	0	0	0
OS 2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0		0	0	0	0	0	0	0
AOS 3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0		0	0	0	0	0	0
OS 3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0		0	0	0	0	0
OS 8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0	0	0	0
AOS 2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0		0	0	0
OS 7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0		0	0
AOS 4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0		0
C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	

H.5 Question 4



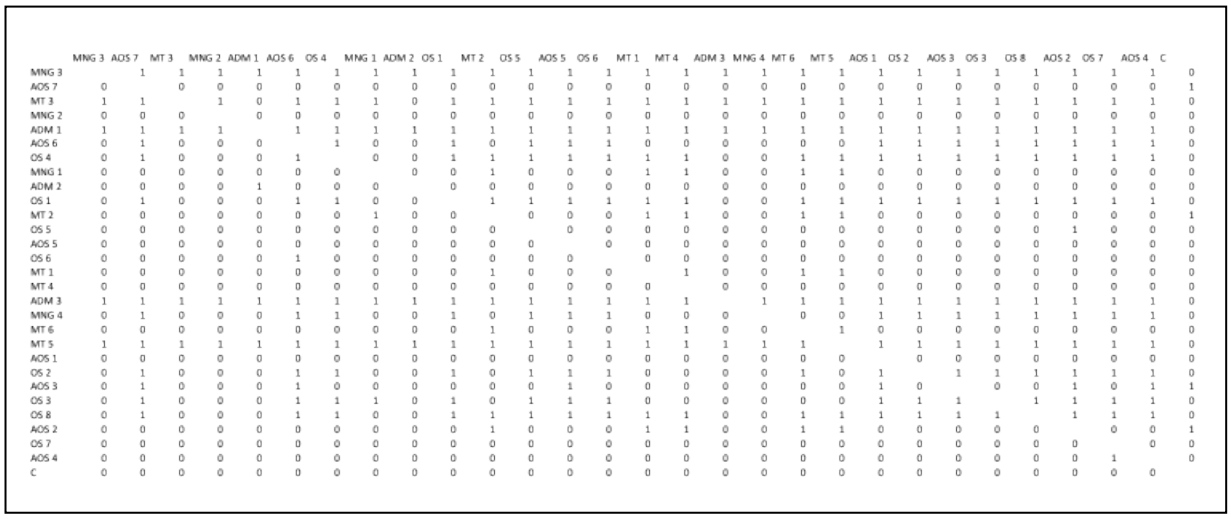
	MNG 3	AOS 7	MT 3	MNG 2	ADM 1	AOS 6	OS 4	MNG 1	ADM 2	OS 1	MT 2	OS 5	AOS 5	OS 6	MT 1	MT 4	ADM 3	MNG 4	MT 6	MT 5	AOS 1	OS 2	AOS 3	OS 3	OS 8	AOS 2	OS 7	AOS 4	C
MNG 3		1	0	0	0	1	1	0	0	1	0	1	1	1	0	0	0	0	0	0	1	1	1	1	1	1	1	1	0
AOS 7	1		0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
MT 3	1	0		0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MNG 2	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
ADM 1	0	0	0	0		0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AOS 6	1	1	0	1	0		1	0	0	1	0	1	1	1	0	0	0	0	0	0	1	1	1	1	1	1	1	1	0
OS 4	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MNG 1	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
ADM 2	0	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
OS 1	1	1	0	0	0	1	1	1	0		0	1	1	1	0	0	0	0	0	0	1	1	1	1	1	1	1	1	0
MT 2	0	0	1	0	1	0	0	0	0	0		1	0	0	1	1	0	0	1	1	0	0	0	0	0	0	0	0	0
OS 5	0	1	0	0	0	1	1	0	0	1	1		1	1	1	1	0	0	1	1	1	1	1	1	1	1	1	1	0
AOS 5	1	0	0	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
OS 6	1	0	0	0	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MT 1	0	0	0	0	0	0	0	1	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0
MT 4	1	0	0	1	0	0	0	1	0	0	0	0	0	0	0		0	1	0	0	0	0	0	0	0	0	0	0	0
ADM 3	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0		1	0	0	0	0	0	0	0	0	0	0	0
MNG 4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0
MT 6	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	1	0	0		1	0	0	0	0	0	0	0	0	0
MT 5	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	1	0	0	1		0	0	0	0	0	0	0	0	0
AOS 1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0
OS 2	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	1	0	0	1	1	0		0	0	0	0	0	0	0
AOS 3	0	1	0	0	0	1	1	0	0	1	0	1	1	1	0	0	0	0	0	0	1	1		1	1	1	1	1	0
OS 3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0	0	0	0	0
OS 8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0	0	0	0
AOS 2	0	0	0	0	1	0	0	0	0	0	1	1	0	0	0	1	0	0	0	0	0	0	0	1	0		0	0	0
OS 7	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1		1	0
AOS 4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0
C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	

H.6 Question 5.1



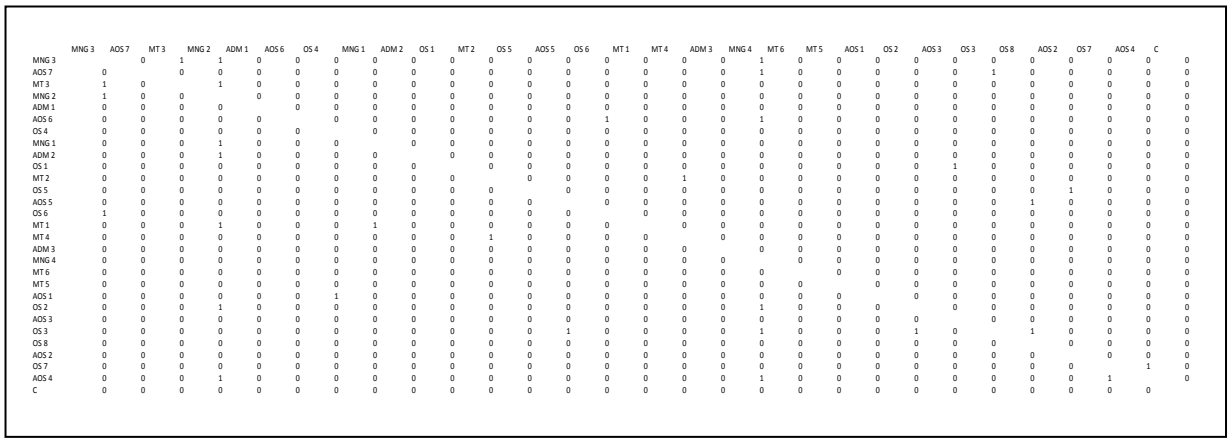
	MNG 3	AOS 7	MT 3	MNG 2	ADM 1	AOS 6	OS 4	MNG 1	ADM 2	OS 1	MT 2	OS 5	AOS 5	OS 6	MT 1	MT 4	ADM 3	MNG 4	MT 6	MT 5	AOS 1	OS 2	AOS 3	OS 3	OS 8	AOS 2	OS 7	AOS 4	C
MNG 3		0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
AOS 7	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
MT 3	1	0		1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MNG 2	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
ADM 1	1	0	0	1		0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AOS 6	0	0	0	0	0		0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
OS 4	1	0	0	1	0	0		1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
MNG 1	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
ADM 2	0	0	0	1	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
OS 1	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0
MT 2	0	0	0	0	0	0	0	1	0	0		1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
OS 5	1	0	0	1	0	0	0	1	0	0	1		0	0	1	1	0	1	1	0	0	0	0	0	0	0	0	0	0
AOS 5	0	0	0	0	0	0	0	0	0	0	0	0		0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0
OS 6	0	0	0	0	0	0	0	0	0	0	0	0	0		0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
MT 1	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0
MT 4	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0
ADM 3	1	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0		1	0	0	0	0	0	0	0	0	0	0	0
MNG 4	1	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0
MT 6	0	0	0	0	0	0	0	1	0	0	1	0	0	0	1	1	0	0		1	0	0	0	0	0	0	0	0	0
MT 5	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	1	0	0	1		0	0	0	0	0	0	0	0	0
AOS 1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0
OS 2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0		0	0	0	0	0	0	0
AOS 3	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0
OS 3	1	1	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0		0	0	0	0	0
OS 8	1	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0		0	0	0	0
AOS 2	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0		0	0	0
OS 7	1	0	0	0	1	0	0	0	0	0	1	0	0	0	1	1	0	1	1	1	0	0	0	0	0	0		0	0
AOS 4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1		0
C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	

H.7 Question 5.2



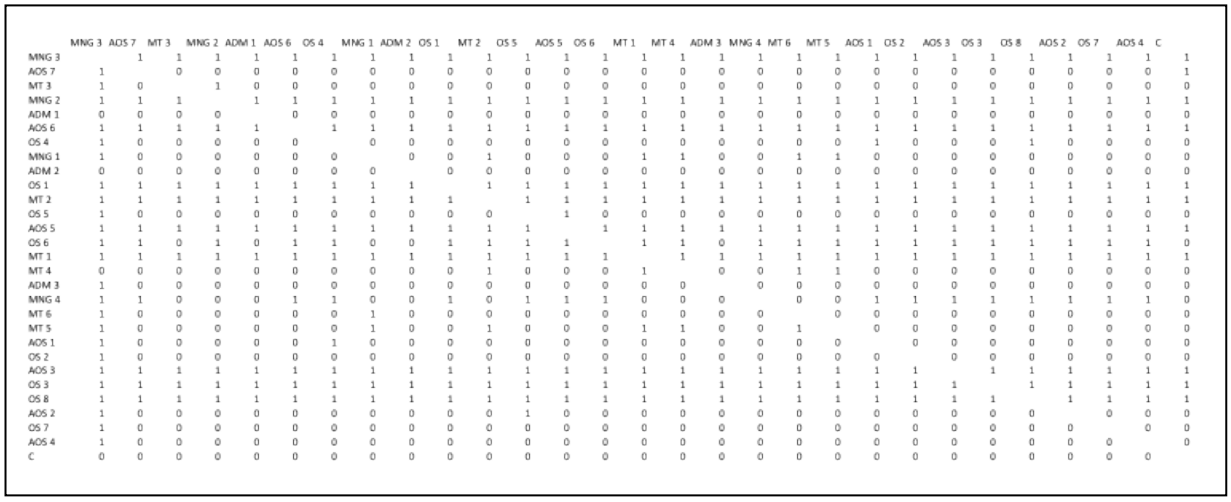
	MNG 3	AOS 7	MT 3	MNG 2	ADM 1	AOS 6	OS 4	MNG 1	ADM 2	OS 1	MT 2	OS 5	AOS 5	OS 6	MT 1	MT 4	ADM 3	MNG 4	MT 6	MT 5	AOS 1	OS 2	AOS 3	OS 3	OS 8	AOS 2	OS 7	AOS 4	C
MNG 3		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0
AOS 7	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
MT 3	1	1		1	0	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0
MNG 2	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
ADM 1	1	1	1	1		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0
AOS 6	0	1	0	0	0		1	0	0	1	0	1	1	1	0	0	0	0	0	0	1	1	1	1	1	1	1	1	0
OS 4	0	1	0	0	0	1		0	0	1	1	1	1	1	1	1	0	0	1	1	1	1	1	1	1	1	1	1	0
MNG 1	0	0	0	0	0	0	0		0	0	1	0	0	0	1	1	0	0	1	1	0	0	0	0	0	0	0	0	0
ADM 2	0	0	0	0	1	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
OS 1	0	1	0	0	0	1	1	0	0		1	1	1	1	1	1	0	0	1	1	1	1	1	1	1	1	1	1	0
MT 2	0	0	0	0	0	0	0	0	0	0		0	0	0	1	1	0	0	1	1	0	0	0	0	0	0	0	0	1
OS 5	0	0	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
AOS 5	0	0	0	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
OS 6	0	0	0	0	0	1	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MT 1	0	0	0	0	0	0	0	0	0	0	1	0	0	0		1	0	0	1	1	0	0	0	0	0	0	0	0	0
MT 4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0
ADM 3	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1		1	1	1	1	1	1	1	1	1	1	1	0
MNG 4	0	1	0	0	0	1	1	0	0	1	0	1	1	1	0	0	0		0	0	1	1	1	1	1	1	1	1	0
MT 6	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	1	0	0		1	0	0	0	0	0	0	0	0	0
MT 5	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1		1	1	1	1	1	1	1	1	0
AOS 1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0
OS 2	0	1	0	0	0	1	1	0	0	1	0	1	1	1	0	0	0	0	0	0	1		1	1	1	1	1	1	0
AOS 3	0	1	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0		0	0	1	0	1	1
OS 3	0	1	0	0	0	1	1	1	0	1	0	1	1	1	0	0	0	0	0	0	1	1	1		1	1	1	1	0
OS 8	0	1	0	0	0	1	1	0	0	1	1	1	1	1	1	1	0	0	1	1	1	1	1	1		1	1	1	0
AOS 2	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	1	0	0	1	1	0	0	0	0	0		0	0	1
OS 7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0	0
AOS 4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1		0
C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	

H.8 Question 6



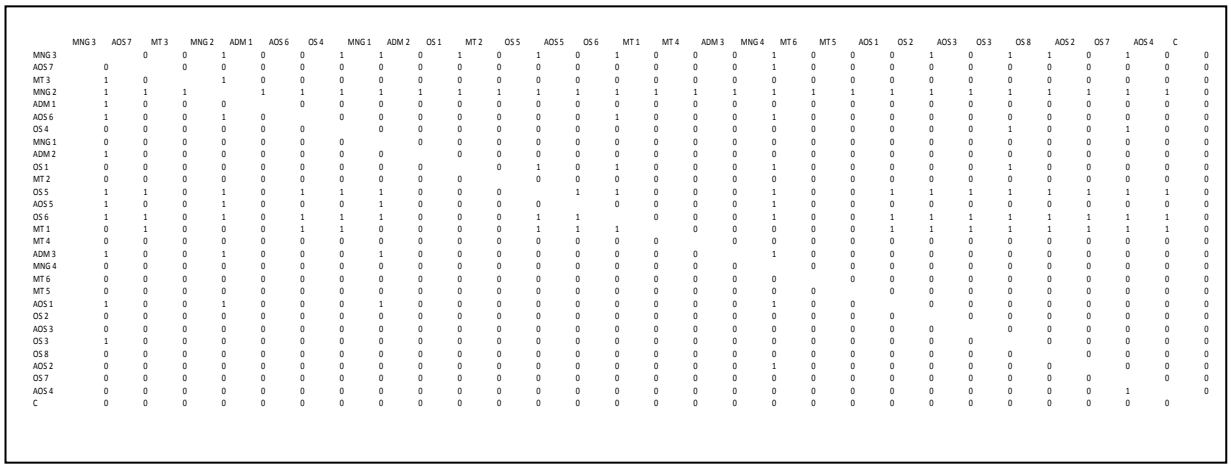
	MNG 3	AOS 7	MT 3	MNG 2	ADM 1	AOS 6	OS 4	MNG 1	ADM 2	OS 1	MT 2	OS 5	AOS 5	OS 6	MT 1	MT 4	ADM 3	MNG 4	MT 6	MT 5	AOS 1	OS 2	AOS 3	OS 3	OS 8	AOS 2	OS 7	AOS 4	C
MNG 3		0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
AOS 7	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0
MT 3	1	0		1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MNG 2	1	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
ADM 1	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AOS 6	0	0	0	0	0		0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
OS 4	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MNG 1	0	0	0	1	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
ADM 2	0	0	0	1	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
OS 1	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
MT 2	0	0	0	0	0	0	0	0	0	0		0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
OS 5	0	0	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
AOS 5	0	0	0	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
OS 6	1	0	0	0	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MT 1	0	0	0	1	0	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0
MT 4	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0
ADM 3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0
MNG 4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0
MT 6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0
MT 5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0
AOS 1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0
OS 2	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0		0	0	0	0	0	0	0
AOS 3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0
OS 3	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	1	0		1	0	0	0	0
OS 8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0	0	0	0
AOS 2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0	0	0
OS 7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		1	0
AOS 4	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1		0
C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	

H.9 Question 7



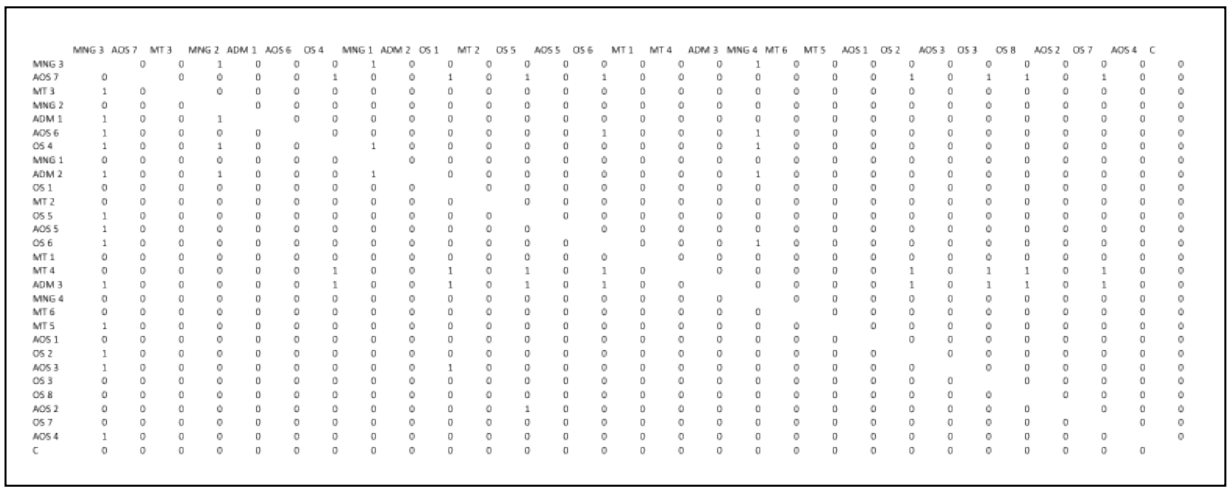
	MNG 3	AOS 7	MT 3	MNG 2	ADM 1	AOS 6	OS 4	MNG 1	ADM 2	OS 1	MT 2	OS 5	AOS 5	OS 6	MT 1	MT 4	ADM 3	MNG 4	MT 6	MT 5	AOS 1	OS 2	AOS 3	OS 3	OS 8	AOS 2	OS 7	AOS 4	C
MNG 3		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
AOS 7	1		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
MT 3	1	0		1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MNG 2	1	1	1		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
ADM 1	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AOS 6	1	1	1	1	1		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
OS 4	1	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0
MNG 1	1	0	0	0	0	0	0		0	0	1	0	0	0	1	1	0	0	1	1	0	0	0	0	0	0	0	0	0
ADM 2	0	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
OS 1	1	1	1	1	1	1	1	1	1		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
MT 2	1	1	1	1	1	1	1	1	1	1		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
OS 5	1	0	0	0	0	0	0	0	0	0	0		1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AOS 5	1	1	1	1	1	1	1	1	1	1	1	1		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
OS 6	1	1	0	1	0	1	1	0	0	1	1	1	1		1	1	0	1	1	1	1	1	1	1	1	1	1	1	0
MT 1	1	1	1	1	1	1	1	1	1	1	1	1	1	1		1	1	1	1	1	1	1	1	1	1	1	1	1	1
MT 4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1		0	0	1	1	0	0	0	0	0	0	0	0	0
ADM 3	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0
MNG 4	1	1	0	0	0	1	1	0	0	1	0	1	1	1	0	0	0		0	0	1	1	1	1	1	1	1	1	0
MT 6	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0
MT 5	1	0	0	0	0	0	0	1	0	0	1	0	0	0	1	1	0	0	1		0	0	0	0	0	0	0	0	0
AOS 1	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0
OS 2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0	0
AOS 3	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1		1	1	1	1	1	1
OS 3	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1		1	1	1	1	1
OS 8	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1		1	1	1	1
AOS 2	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0		0	0	0
OS 7	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0	0
AOS 4	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0
C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	

H.10 Question 9



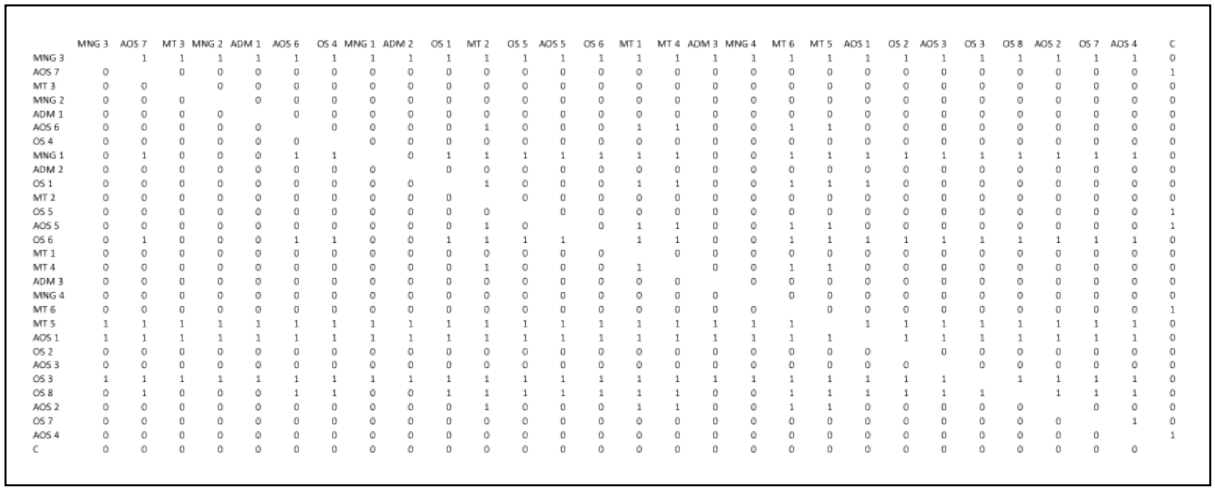
	MNG 3	AOS 7	MT 3	MNG 2	ADM 1	AOS 6	OS 4	MNG 1	ADM 2	OS 1	MT 2	OS 5	AOS 5	OS 6	MT 1	MT 4	ADM 3	MNG 4	MT 6	MT 5	AOS 1	OS 2	AOS 3	OS 3	OS 8	AOS 2	OS 7	AOS 4	C
MNG 3		0	0	1	0	0	1	1	0	1	0	1	0	1	0	0	0	1	0	0	0	1	0	1	1	0	1	0	0
AOS 7	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
MT 3	1	0		1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MNG 2	1	1	1		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0
ADM 1	1	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AOS 6	1	0	0	1	0		0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
OS 4	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0
MNG 1	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
ADM 2	1	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
OS 1	0	0	0	0	0	0	0	0	0		0	1	0	1	0	1	0	0	0	0	1	0	0	0	1	0	0	0	0
MT 2	0	0	0	0	0	0	0	0	0	0		0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
OS 5	1	1	0	1	0	1	1	1	0	0	0		1	1	0	0	0	1	0	0	1	1	1	1	1	1	1	1	0
AOS 5	1	0	0	1	0	0	0	1	0	0	0	0		0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0
OS 6	1	1	0	1	0	1	1	1	0	0	0	0	1		0	0	0	1	0	0	1	1	1	1	1	1	1	1	0
MT 1	0	1	0	0	0	1	1	0	0	0	0	0	1	1		0	0	0	0	0	1	1	1	1	1	1	1	1	0
MT 4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0
ADM 3	1	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0		1	0	0	0	0	0	0	0	0	0	0	0
MNG 4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0
MT 6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0
MT 5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0
AOS 1	1	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0		0	0	0	0	0	0	0	0
OS 2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0	0
AOS 3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0
OS 3	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0	0	0	0	0
OS 8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0	0	0	0
AOS 2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0		0	0	0
OS 7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0	0
AOS 4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	

H.11 Question 10.1



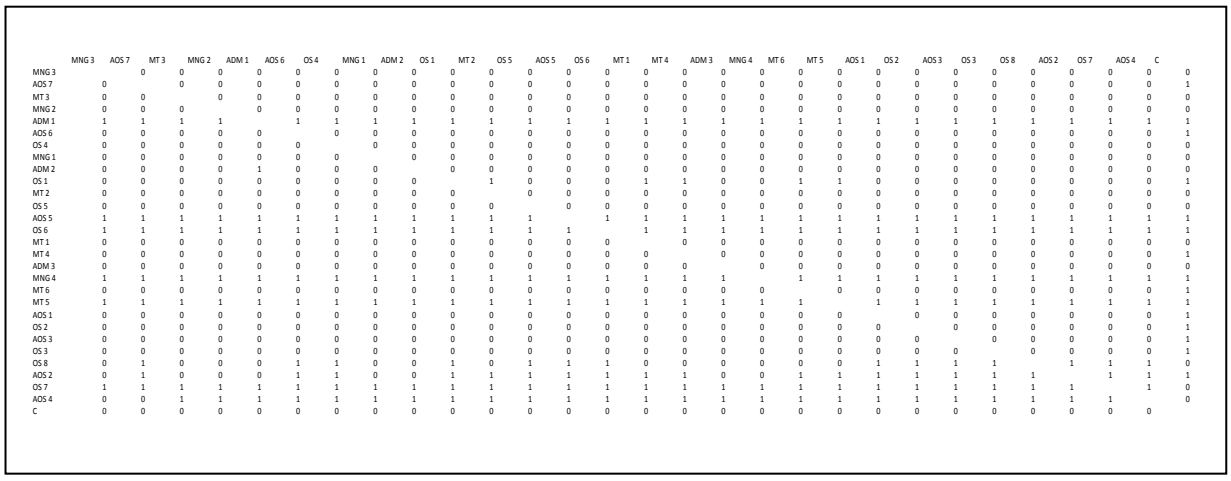
	MNG 3	AOS 7	MT 3	MNG 2	ADM 1	AOS 6	OS 4	MNG 1	ADM 2	OS 1	MT 2	OS 5	AOS 5	OS 6	MT 1	MT 4	ADM 3	MNG 4	MT 6	MT 5	AOS 1	OS 2	AOS 3	OS 3	OS 8	AOS 2	OS 7	AOS 4	C
MNG 3		0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
AOS 7	0		0	0	0	0	0	1	0	0	1	0	1	0	1	0	0	0	0	0	0	0	1	0	1	1	0	1	0
MT 3	1	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MNG 2	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
ADM 1	1	0	0	1		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AOS 6	1	0	0	0	0		0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
OS 4	1	0	0	1	0	0		1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
MNG 1	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
ADM 2	1	0	0	1	0	0	0	1		0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
OS 1	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MT 2	0	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
OS 5	1	0	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AOS 5	1	0	0	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
OS 6	1	0	0	0	0	0	0	0	0	0	0	0	0		0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
MT 1	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0
MT 4	0	0	0	0	0	0	0	1	0	0	0	0	1	0	1		0	0	0	0	0	0	1	0	1	1	0	1	0
ADM 3	1	0	0	0	0	0	0	1	0	0	1	0	1	0	1	0	0		0	0	0	0	1	0	1	1	0	1	0
MNG 4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0
MT 6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0
MT 5	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0
AOS 1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0	0
OS 2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0
AOS 3	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0		0	0	0	0	0
OS 3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0	0	0	0
OS 8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0	0	0
AOS 2	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0		0	0
OS 7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0
AOS 4	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	

H.12 Question 10.2



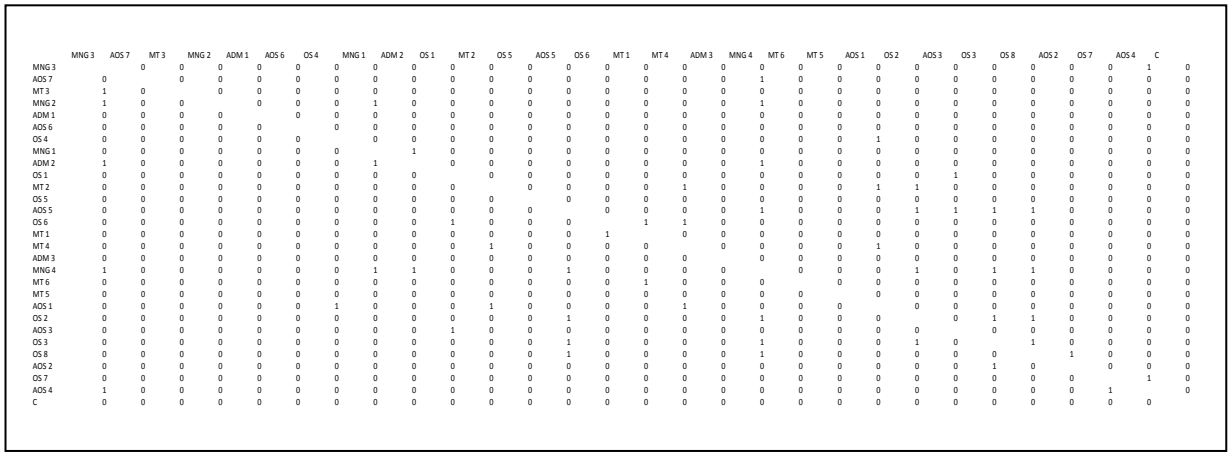
	MNG 3	AOS 7	MT 3	MNG 2	ADM 1	AOS 6	OS 4	MNG 1	ADM 2	OS 1	MT 2	OS 5	AOS 5	OS 6	MT 1	MT 4	ADM 3	MNG 4	MT 6	MT 5	AOS 1	OS 2	AOS 3	OS 3	OS 8	AOS 2	OS 7	AOS 4	C
MNG 3		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0
AOS 7	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
MT 3	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MNG 2	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
ADM 1	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AOS 6	0	0	0	0	0		0	0	0	0	1	0	0	0	1	1	0	0	1	1	0	0	0	0	0	0	0	0	0
OS 4	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MNG 1	0	1	0	0	0	1	1		0	1	1	1	1	1	1	1	0	0	1	1	1	1	1	1	1	1	1	1	0
ADM 2	0	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
OS 1	0	0	0	0	0	0	0	0	0		1	0	0	0	1	1	0	0	1	1	1	0	0	0	0	0	0	0	0
MT 2	0	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
OS 5	0	0	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
AOS 5	0	0	0	0	0	0	0	0	0	0	0	0		0	1	1	0	0	1	1	0	0	0	0	0	0	0	0	1
OS 6	0	1	0	0	0	1	1	0	0	1	1	1		1	1	0	0	0	1	1	1	1	1	1	1	1	1	1	0
MT 1	0	0	0	0	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MT 4	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1		0	0	1	1	0	0	0	0	0	0	0	0	0
ADM 3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0
MNG 4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0
MT 6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	1
MT 5	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1		1	1	1	1	1	1	1	1	0
AOS 1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1		1	1	1	1	1	1	1	0
OS 2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0	0
AOS 3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0
OS 3	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1		1	1	1	1	0
OS 8	0	1	0	0	0	1	1	0	0	1	1	1	1	1	1	1	0	0	1	1	1	1	1	1		1	1	1	0
AOS 2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	1	1	0	0	0	0	0		0	0	0
OS 7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		1	0
AOS 4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		1
C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	

H.13 Question 11



	MNG 3	AOS 7	MT 3	MNG 2	ADM 1	AOS 6	OS 4	MNG 1	ADM 2	OS 1	MT 2	OS 5	AOS 5	OS 6	MT 1	MT 4	ADM 3	MNG 4	MT 6	MT 5	AOS 1	OS 2	AOS 3	OS 3	OS 8	AOS 2	OS 7	AOS 4	C	
MNG 3		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AOS 7	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
MT 3	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MNG 2	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
ADM 1	1	1	1	1		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
AOS 6	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
OS 4	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MNG 1	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
ADM 2	0	0	0	0	1	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
OS 1	0	0	0	0	0	0	0	0	0		1	0	0	0	0	1	1	0	0	1	1	0	0	0	0	0	0	0	0	1
MT 2	0	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
OS 5	0	0	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AOS 5	1	1	1	1	1	1	1	1	1	1	1	1		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
OS 6	1	1	1	1	1	1	1	1	1	1	1	1	1		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
MT 1	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MT 4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0	1
ADM 3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0
MNG 4	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1		1	1	1	1	1	1	1	1	1	1	1	1
MT 6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	1
MT 5	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1		1	1	1	1	1	1	1	1	1	1
AOS 1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	1
OS 2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0	0	1
AOS 3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0	1
OS 3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0	0	0	0	0	1
OS 8	0	1	0	0	0	1	1	0	0	1	1	1	1	1	1	1	0	0	1	1	1	1	1	1		1	1	1	0	0
AOS 2	0	1	0	0	0	1	1	0	0	1	1	1	1	1	1	1	0	0	1	1	1	1	1	1	1		1	1	1	1
OS 7	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1		1	1	0
AOS 4	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1		1	0
C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		

H.14 Question 12



	MNG 3	AOS 7	MT 3	MNG 2	ADM 1	AOS 6	OS 4	MNG 1	ADM 2	OS 1	MT 2	OS 5	AOS 5	OS 6	MT 1	MT 4	ADM 3	MNG 4	MT 6	MT 5	AOS 1	OS 2	AOS 3	OS 3	OS 8	AOS 2	OS 7	AOS 4	C	
MNG 3		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
AOS 7	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
MT 3	1	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MNG 2	1	0	0		0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
ADM 1	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AOS 6	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
OS 4	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
MNG 1	0	0	0	0	0	0	0		1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
ADM 2	1	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
OS 1	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
MT 2	0	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
OS 5	0	0	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
AOS 5	0	0	0	0	0	0	0	0	0	0	0	0		0	0	0	0	0	1	0	0	0	1	1	1	1	0	0	0	0
OS 6	0	0	0	0	0	0	0	0	0	0	1	0	0		1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MT 1	0	0	0	0	0	0	0	0	0	0	0	0	0	1		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MT 4	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0		0	0	0	0	1	0	0	0	0	0	0	0	0	0
ADM 3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0
MNG 4	1	0	0	0	0	0	0	1	1	0	0	0	0	1	0	0	0		0	0	0	0	1	0	1	1	0	0	0	0
MT 6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0		0	0	0	0	0	0	0	0	0	0	0
MT 5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0
AOS 1	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	1	0	0	0	0		0	0	0	0	0	0	0	0	0
OS 2	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0		1	1	0	0	0	0	0	0
AOS 3	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0	0
OS 3	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0		1	0	0	0	0	0
OS 8	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0		1	0	0	0	0
AOS 2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1		0	0	0	0
OS 7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		1	0	0
AOS 4	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1		0	0
C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		

H.15 Question 13

	MNG 3	AOS 7	MT 3	MNG 2	ADM 1	AOS 6	OS 4	MNG 1	ADM 2	OS 1	MT 2	OS 5	AOS 5	OS 6	MT 1	MT 4	ADM 3	MNG 4	MT 6	MT 5	AOS 1	OS 2	AOS 3	OS 3	OS 8	AOS 2	OS 7	AOS 4	C
MNG 3		0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AOS 7	1		0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
MT 3	1	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MNG 2	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
ADM 1	1	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AOS 6	1	0	0	1	0		0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
OS 4	1	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MNG 1	1	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
ADM 2	1	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
OS 1	0	0	0	1	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MT 2	0	0	0	1	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
OS 5	1	0	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AOS 5	1	0	0	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
OS 6	1	0	0	0	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MT 1	1	0	0	0	0	0	0	0	0	0	0	0	1	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0
MT 4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0
ADM 3	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0
MNG 4	0	0	0	0	0	0	1	0	0	1	0	1	0	1	0	0	0		0	0	0	1	0	1	1	0	1	0	0
MT 6	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0
MT 5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0
AOS 1	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0
OS 2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0	0
AOS 3	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0
OS 3	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0	0	0	0	0
OS 8	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0	0	0	0
AOS 2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0		1	0	0
OS 7	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0	0
AOS 4	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0
C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	